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## Automation of an air-screen seed cleaner

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# Automation of an air-screen seed cleaner

## **Abstract**

A cleaning system is provided for separating desired material from undesirable material in a mixture of particulate materials. The system includes an inlet for receiving the mixture of materials and an outlet for discharging the desired materials. At least one screen is provided for separating undersized material from oversized material within the mixture, and at least one vacuum air-lift is provided for separating the lighter material from the heavier material within the mixture. A first sensor is mounted below the discharge end of the screen for sensing the quantity of undersized material separated by the screen and a second sensor is mounted in the air-lift for sensing the quantity of lighter materials separated by the air-lift. The signals generated by the sensors can be received by a processing unit which adjusts the extent of separation by the screen and by the air-lift to achieve the desired efficiency of the cleaning system.

## **Keywords**

Agricultural and Biosystems Engineering

## **Disciplines**

Agriculture | Bioresource and Agricultural Engineering

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Misra et al.

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[54] AUTOMATION OF AN AIR-SCREEN SEED CLEANER

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[52] U.S. Cl. .... 209/31; 209/37; 209/139.001; 209/257; 209/546; 209/557; 364/502; 364/552

[58] Field of Search ..... 209/21, 30-37, 209/44.1, 44.2, 134-139.1, 146, 147, 149, 153, 154, 237, 238, 255, 257, 546, 549, 552, 555, 557, 629, 639; 55/215, 218, 270, 279, 413, 423-426; 364/500, 502, 552, 555; 406/28, 168, 169, 173

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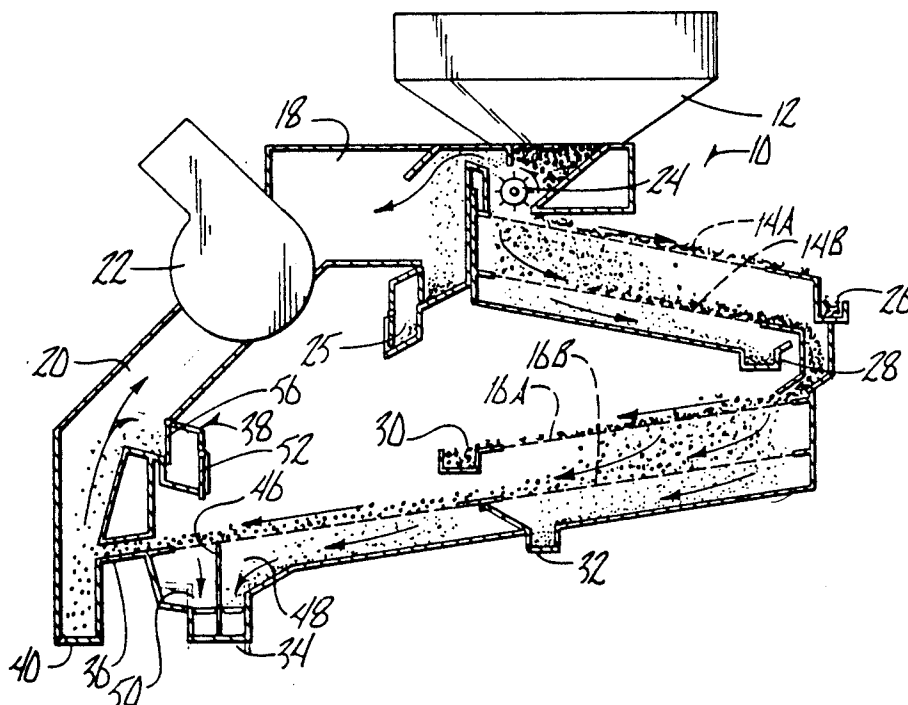
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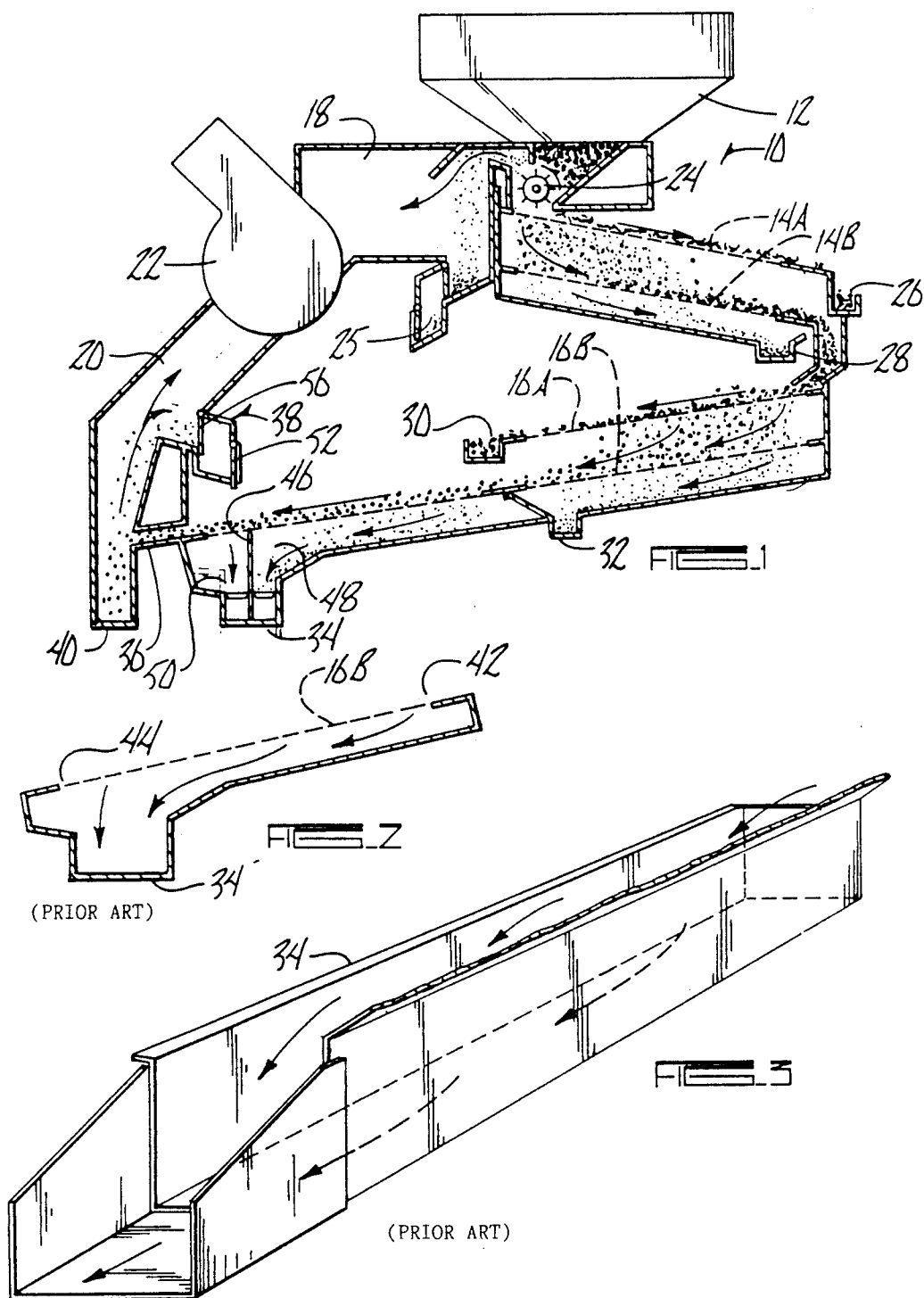
Attorney, Agent, or Firm—Zarley, McKee, Thomte, Voorhees & Sease

## [57] ABSTRACT

A cleaning system is provided for separating desired material from undesirable material in a mixture of particulate materials. The system includes an inlet for receiving the mixture of materials and an outlet for discharging the desired materials. At least one screen is provided for separating undersized material from oversized material within the mixture, and at least one vacuum air-lift is provided for separating the lighter material from the heavier material within the mixture. A first sensor is mounted below the discharge end of the screen for sensing the quantity of undersized material separated by the screen and a second sensor is mounted in the air-lift for sensing the quantity of lighter materials separated by the air-lift. The signals generated by the sensors can be received by a processing unit which adjusts the extent of separation by the screen and by the air-lift to achieve the desired efficiency of the cleaning system.

16 Claims, 23 Drawing Sheets





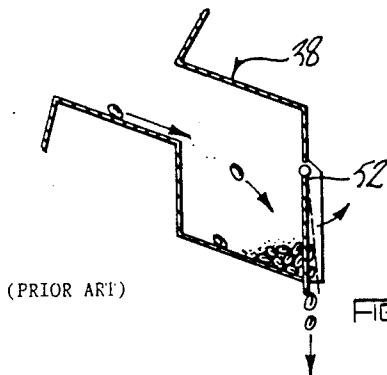
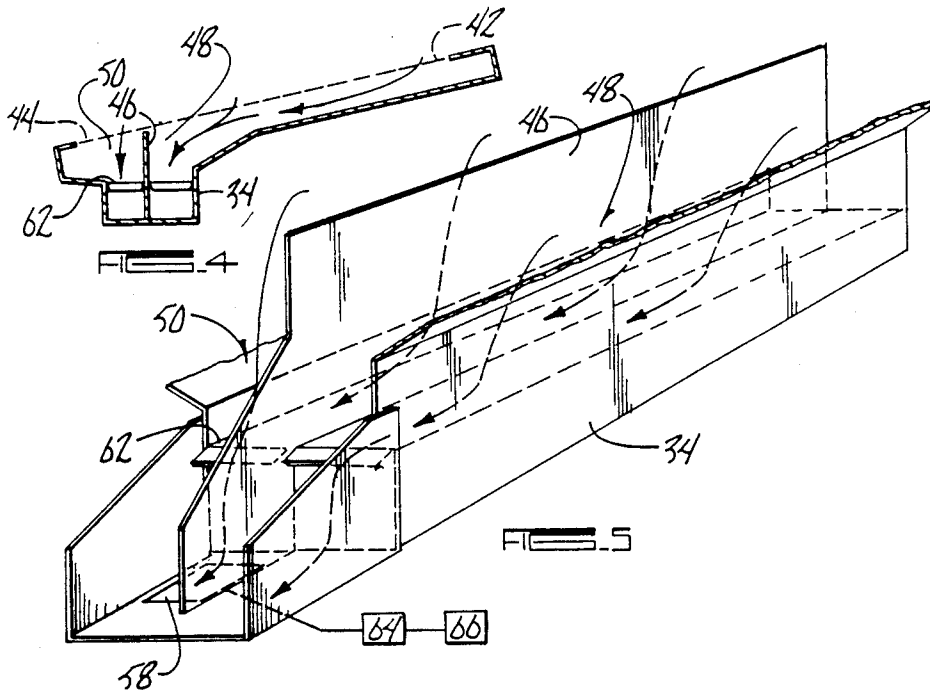


FIG. 6

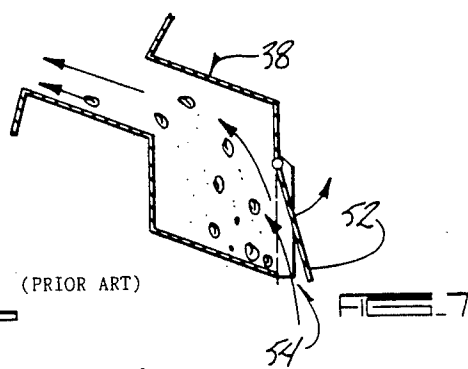


FIG. 7

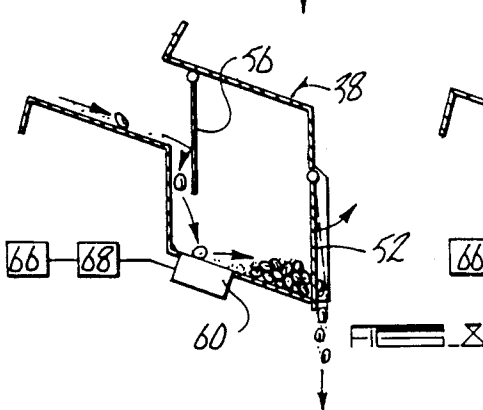


FIG. 8

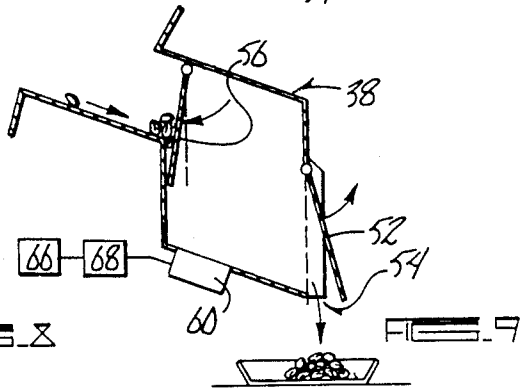


FIG. 9

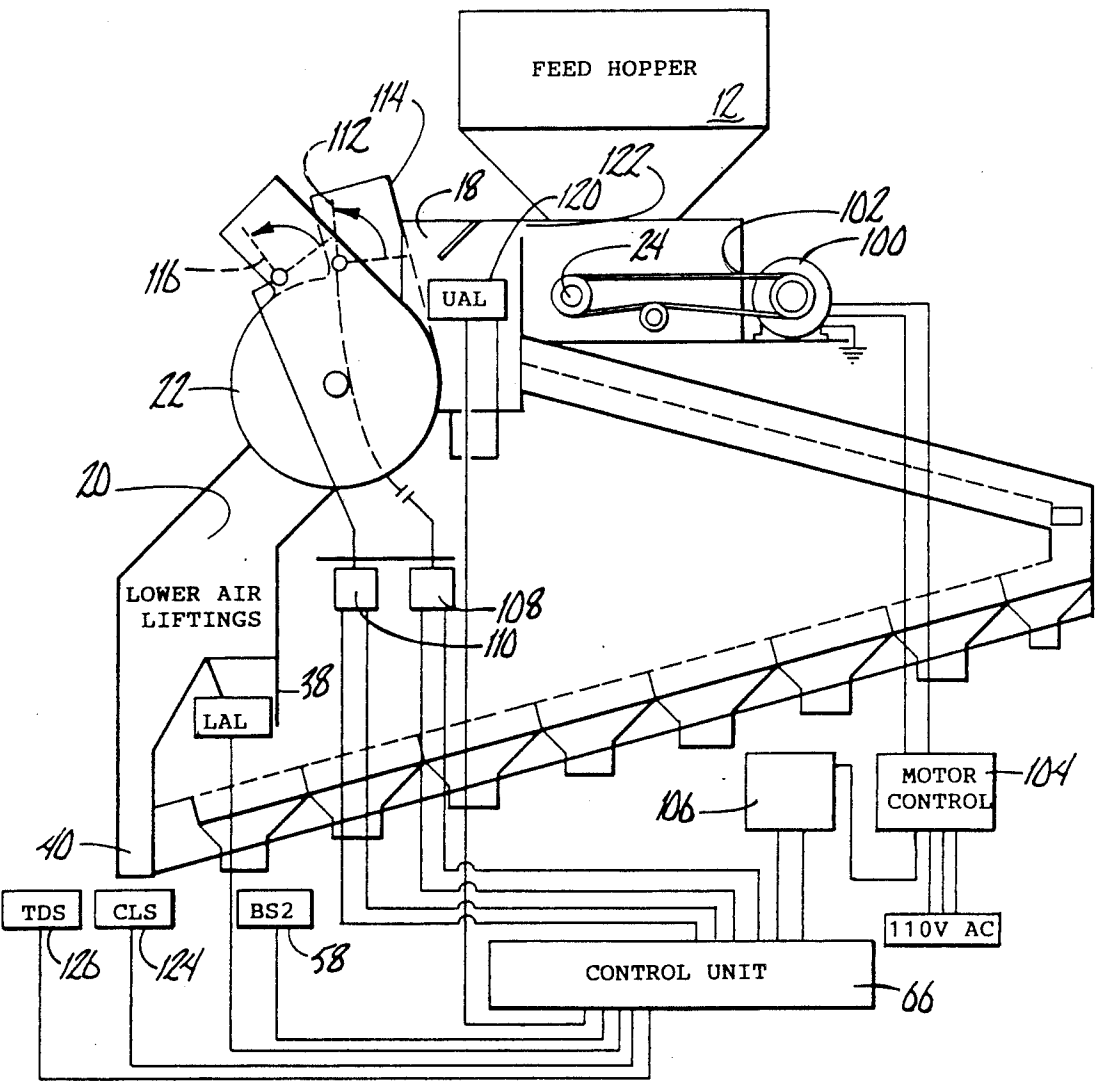
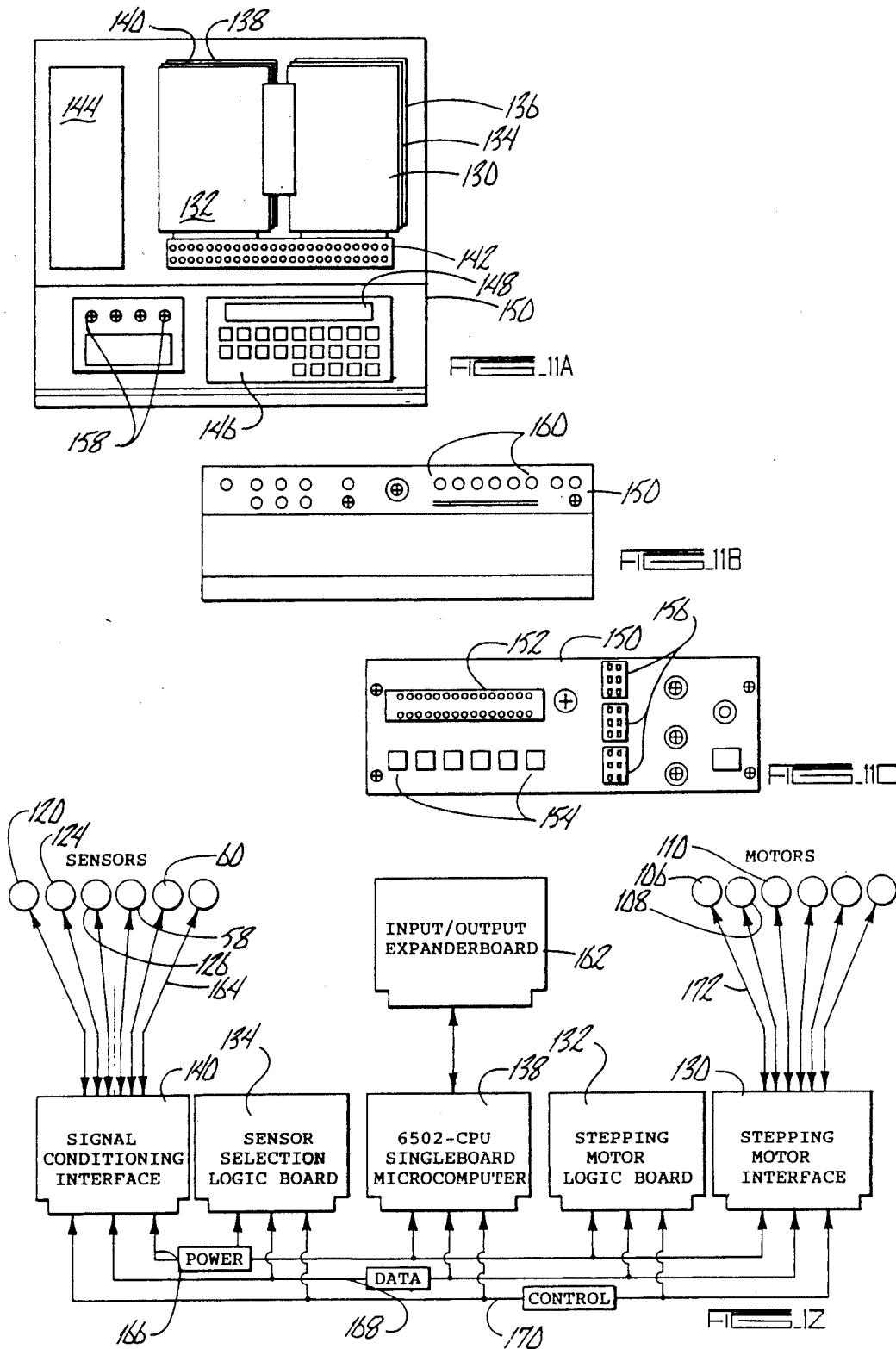
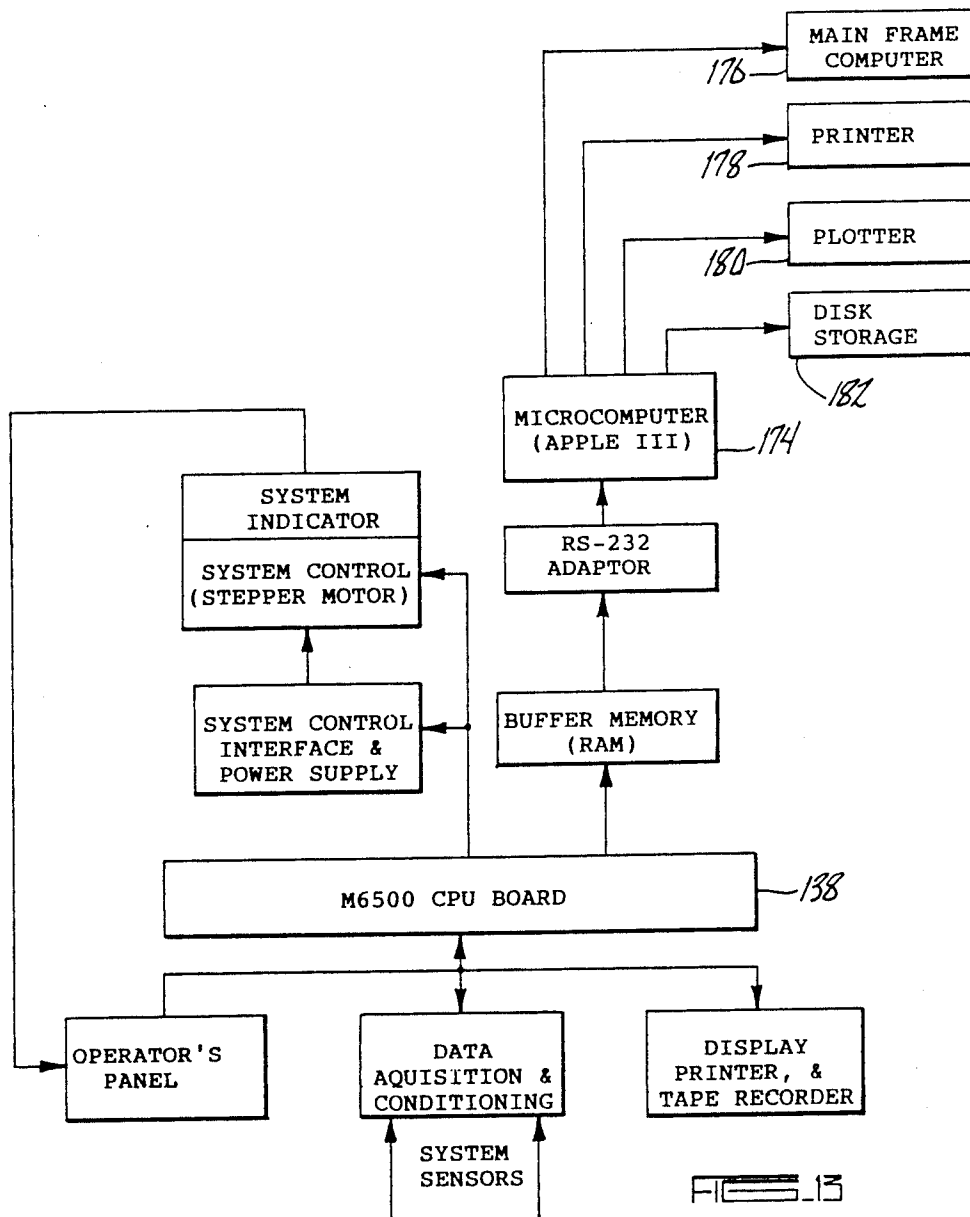
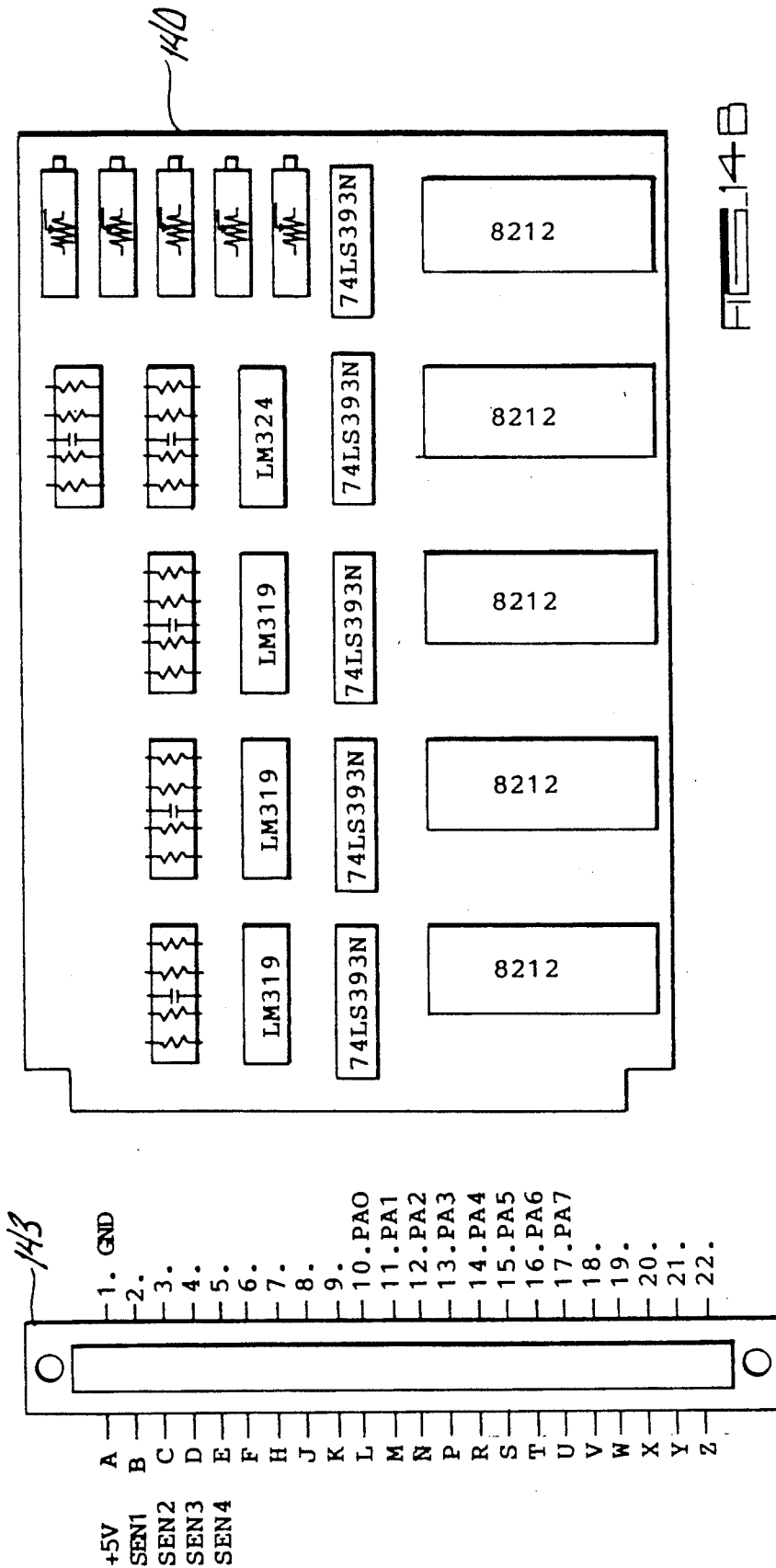


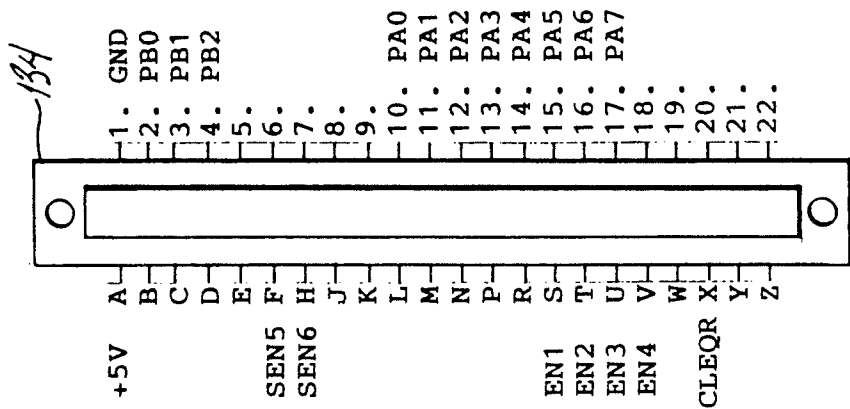
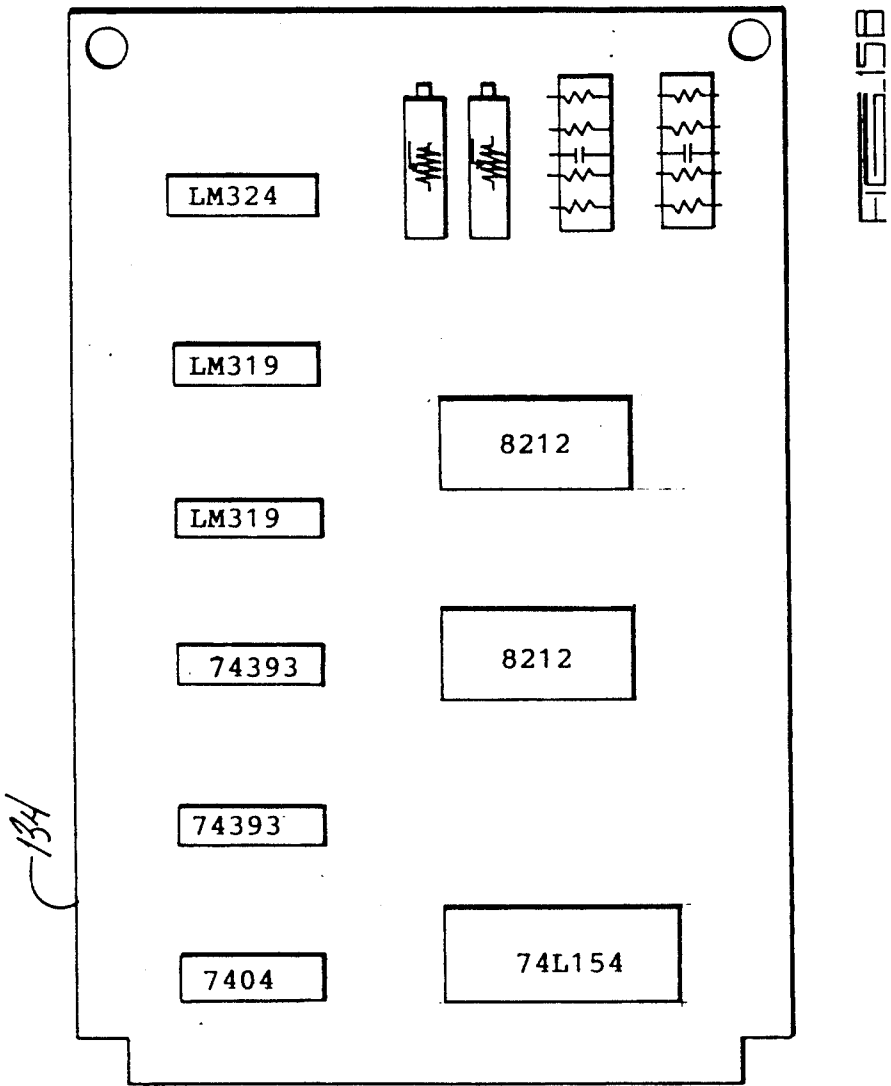
FIG. 10

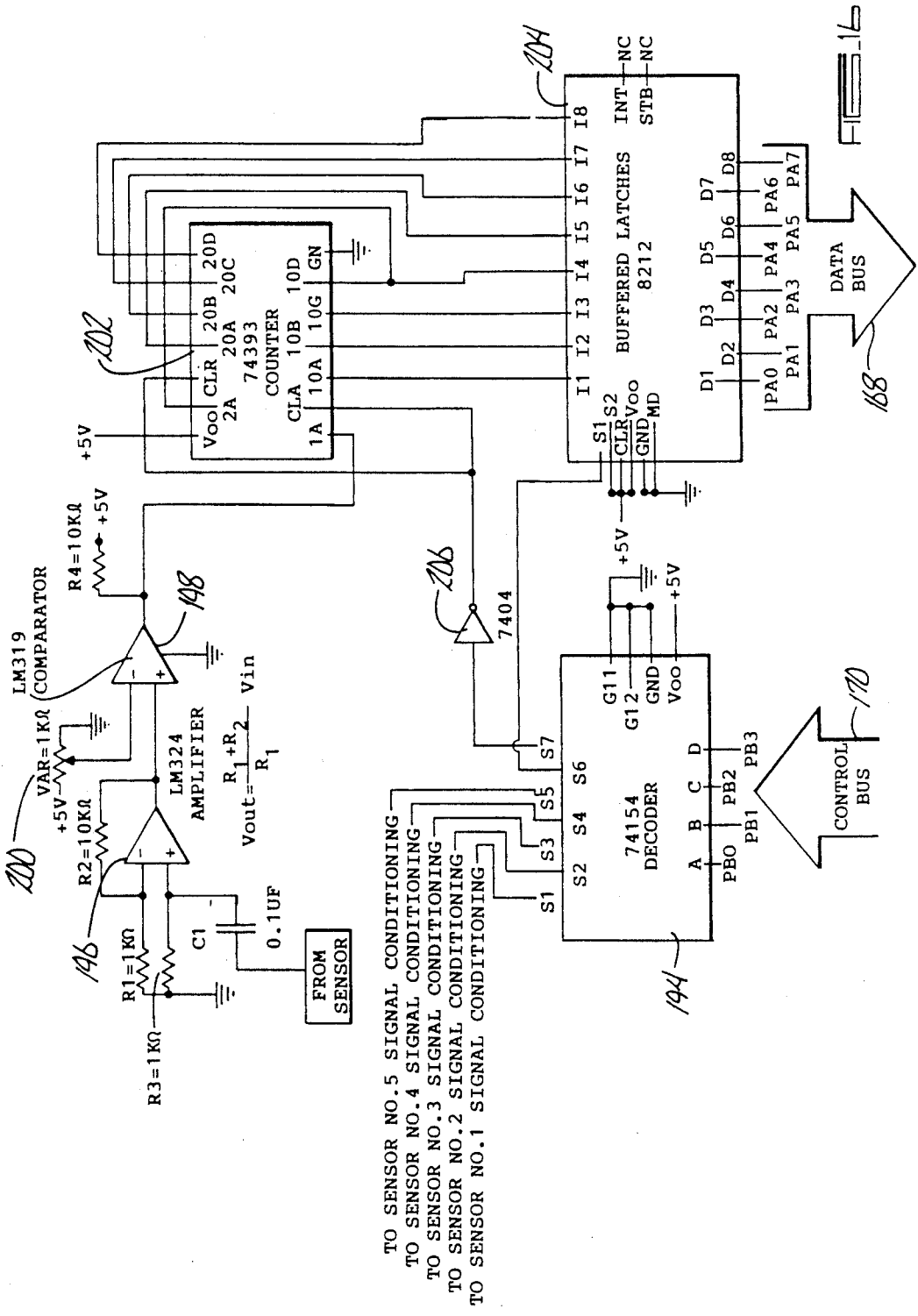












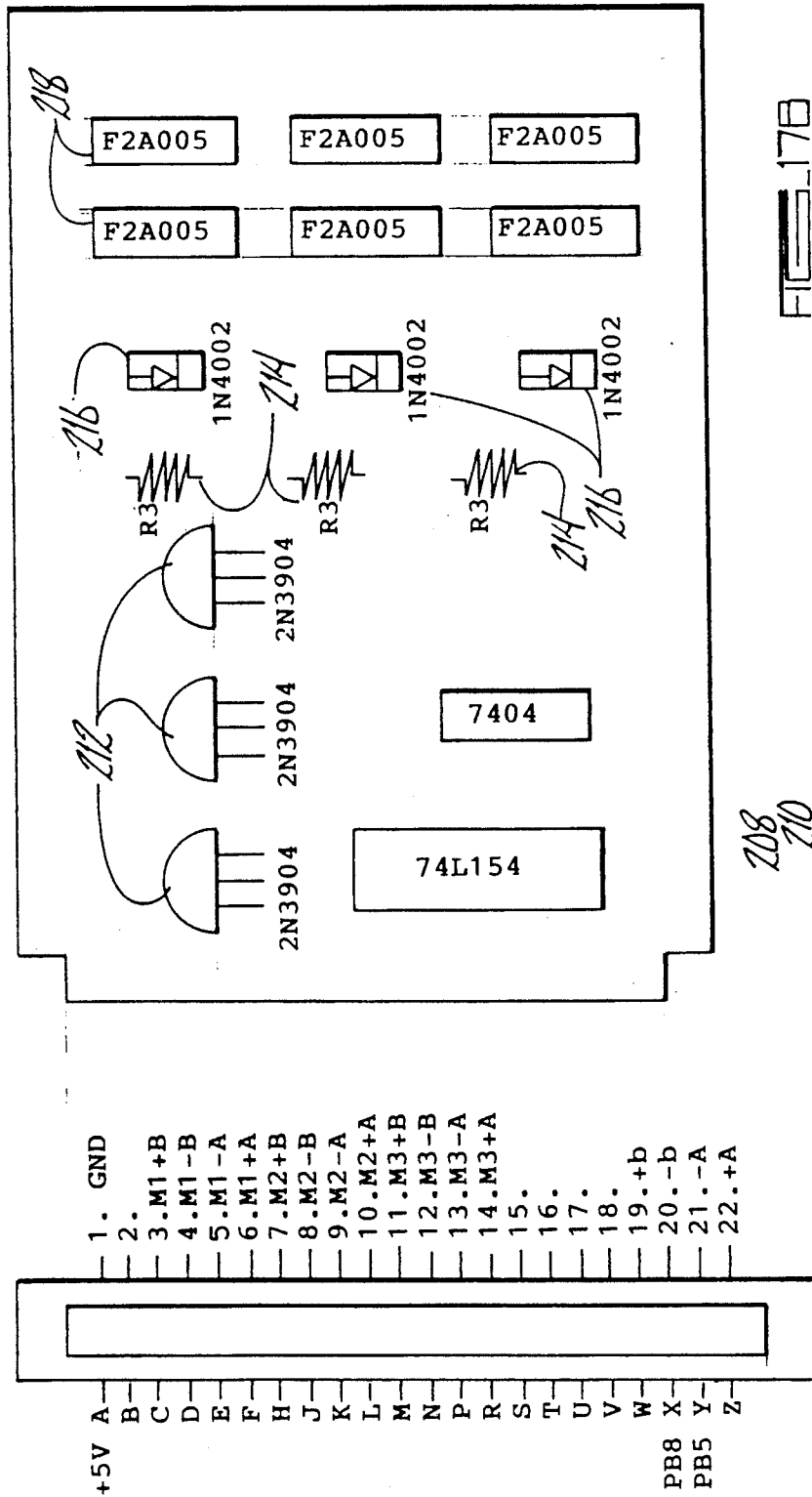
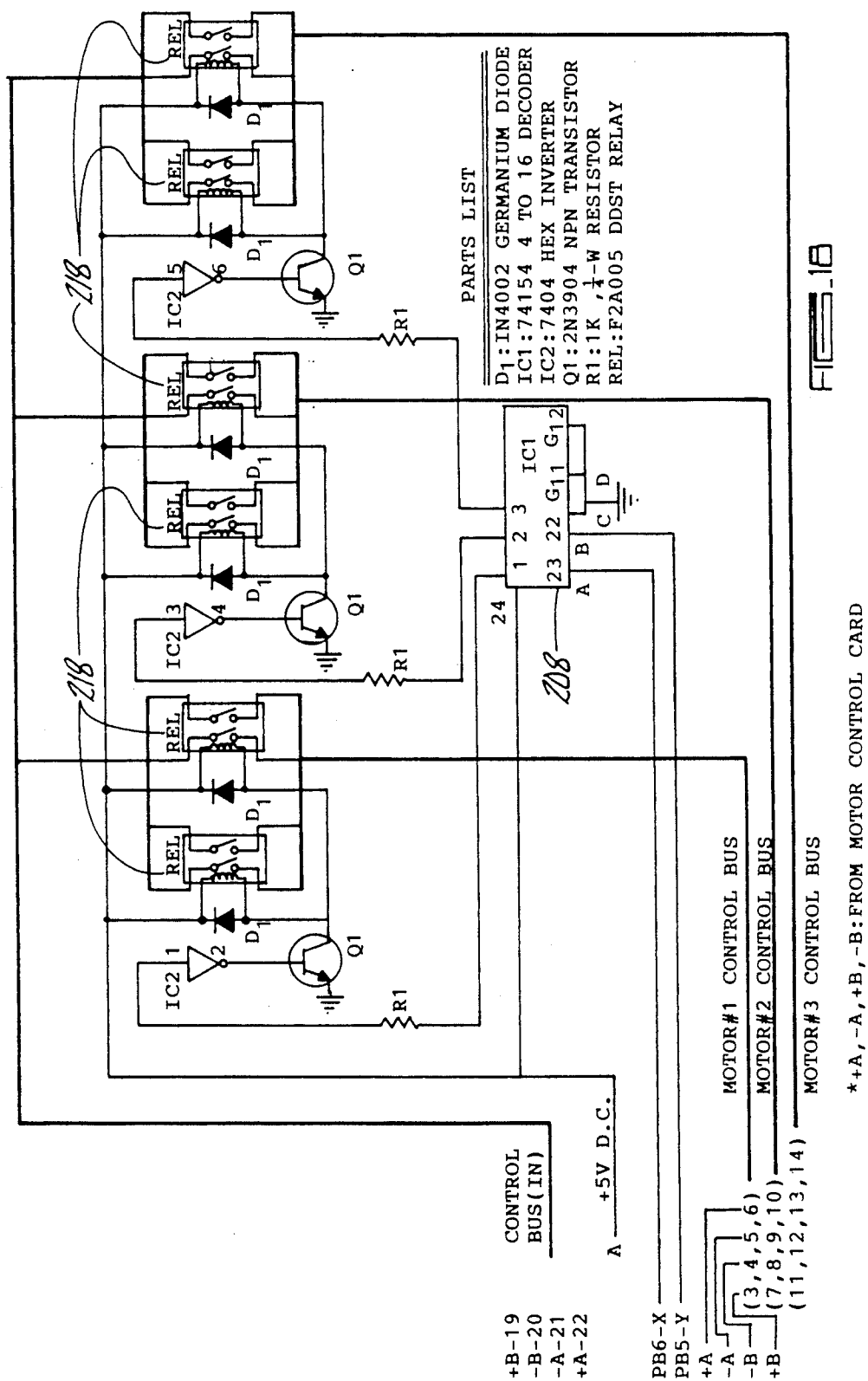


FIG. 17A

FIG. 17B



\*+A, -A, +B, -B: FROM MOTOR CONTROL CARD

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| PORT B<br>VALUE(##) | FUNCTION  | POWER LINE<br>(OUTSIDE) | NOTE |
|---------------------|---|-------------------------|------|
| 60                  | DISABLE   |                         |      |
| 40<br>48            | M#1 CCW(DECREASE LOWER AIR)<br>M#1 CW(INCREASE LOWER AIR) | >+12V DC                |      |
| 20<br>28            | M#2CCW(DECREASE UPPER AIR)<br>M#2 CW(INCREASE UPPER AIR)  | >+12V DC                |      |
| 00<br>08            | M#3CCW(INCREASE FEED RATE)<br>M#3 CW(DECREASE FEED RATE)  | >+12V DC                |      |
|                     |   |                         |      |

FIG. 19A

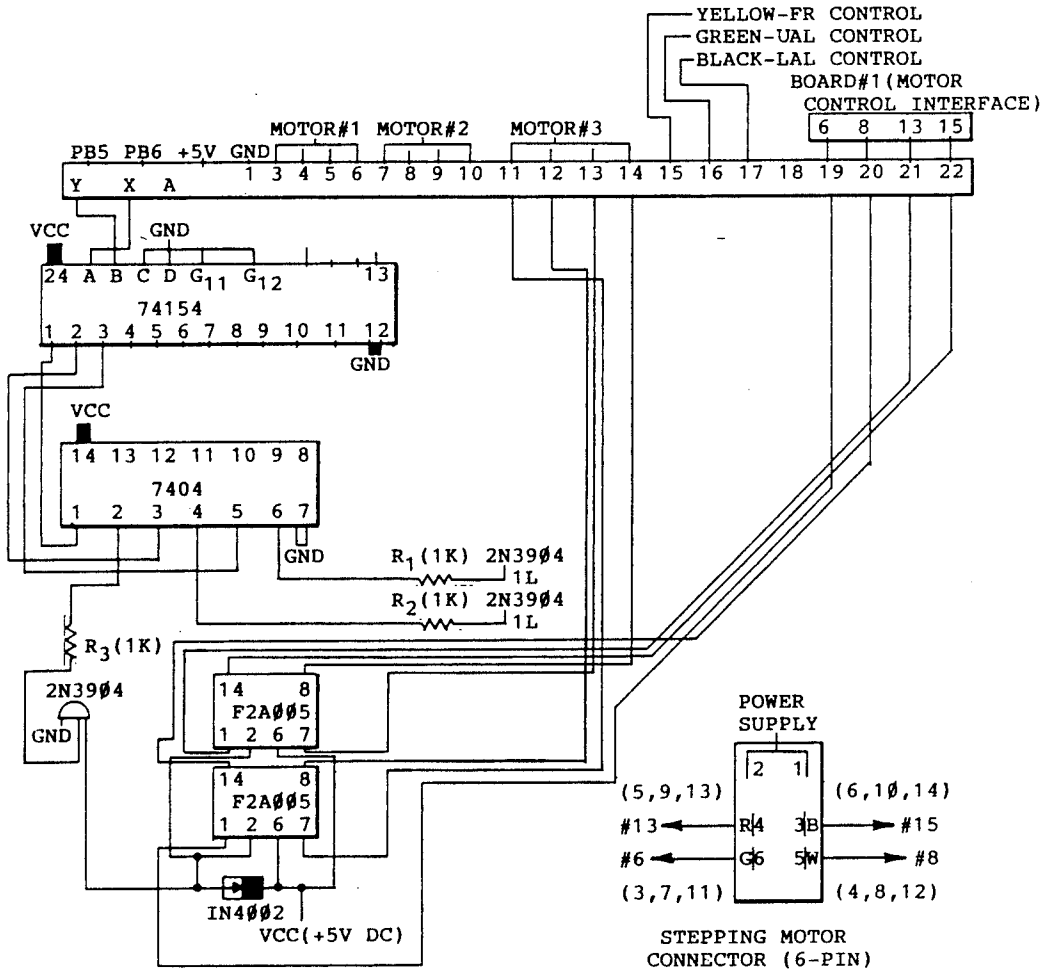
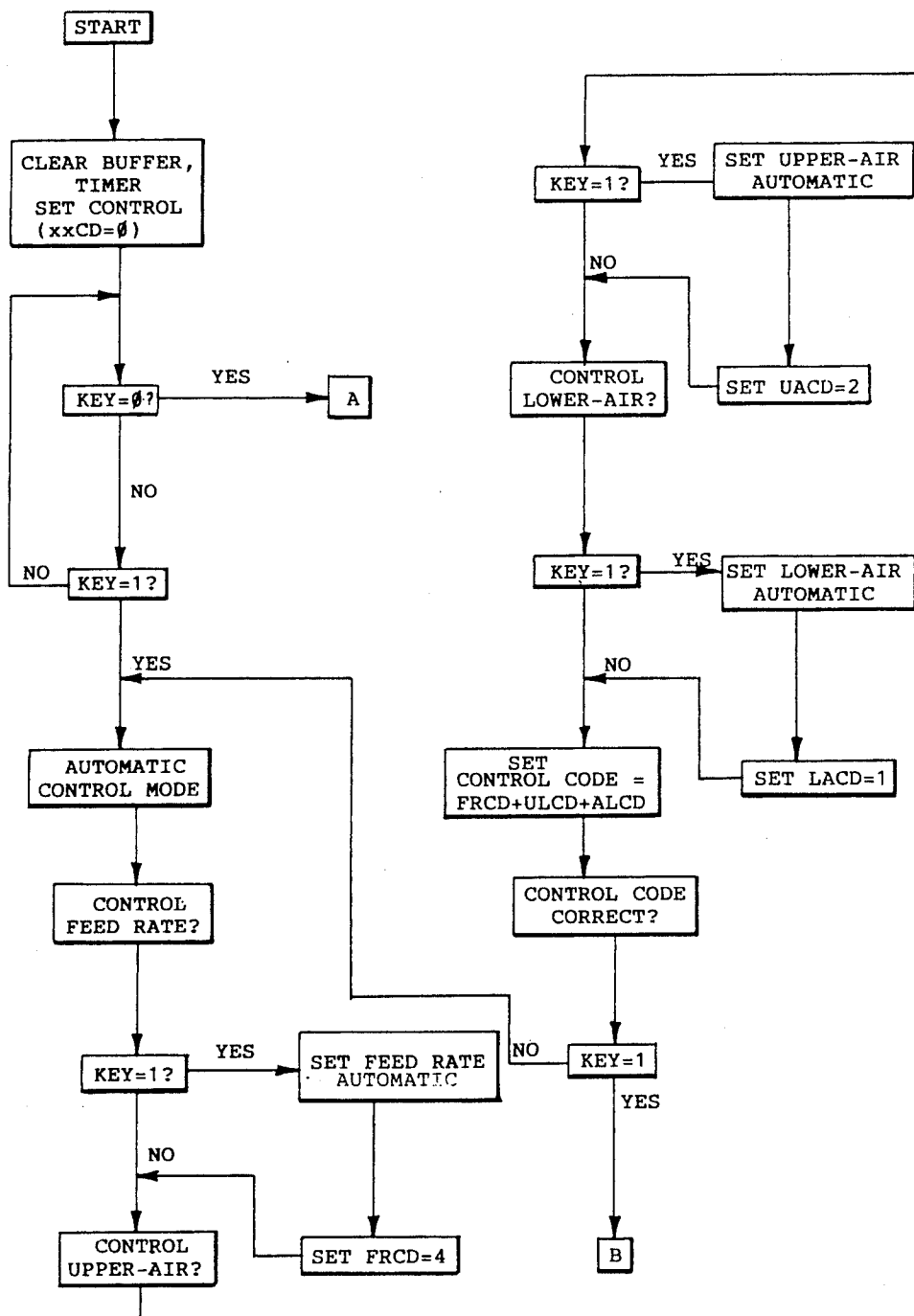
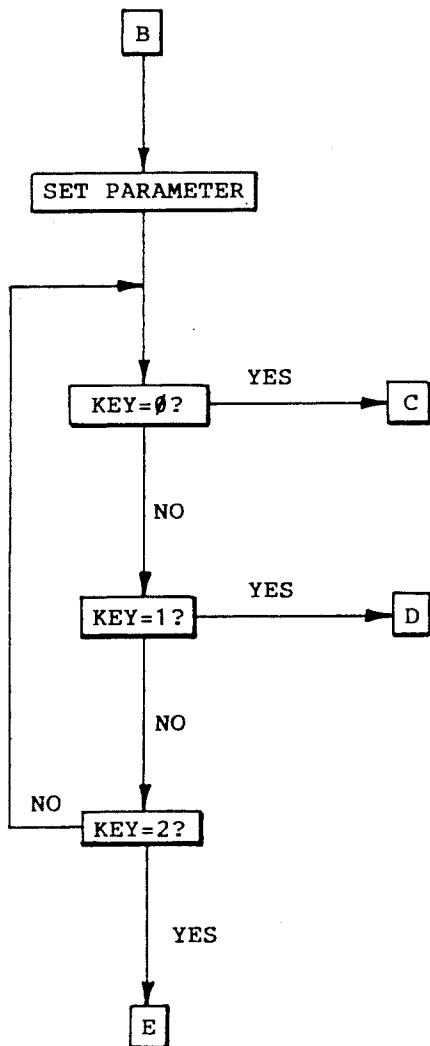


FIG. 19B

FIG. 19C





C: PROGRAM PRESET PARAMETERS ARE USED.  
 D: PARAMETERS GIVEN BY OPERATOR ARE USED.  
 E: PARAMETERS GIVEN BY AUTOMATIC READING PROGRAM ARE USED.

FIG. 21

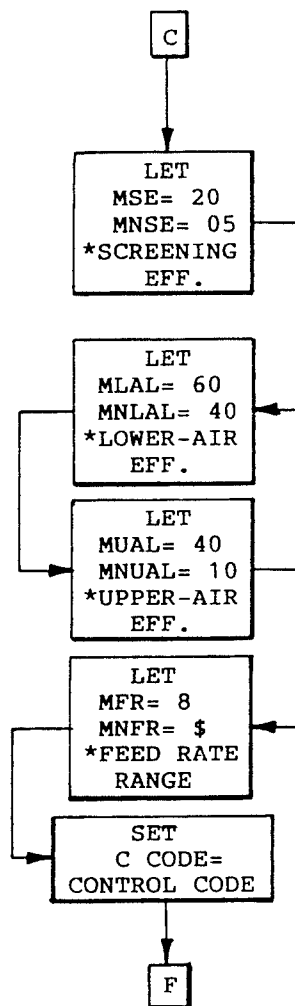


FIG. 22



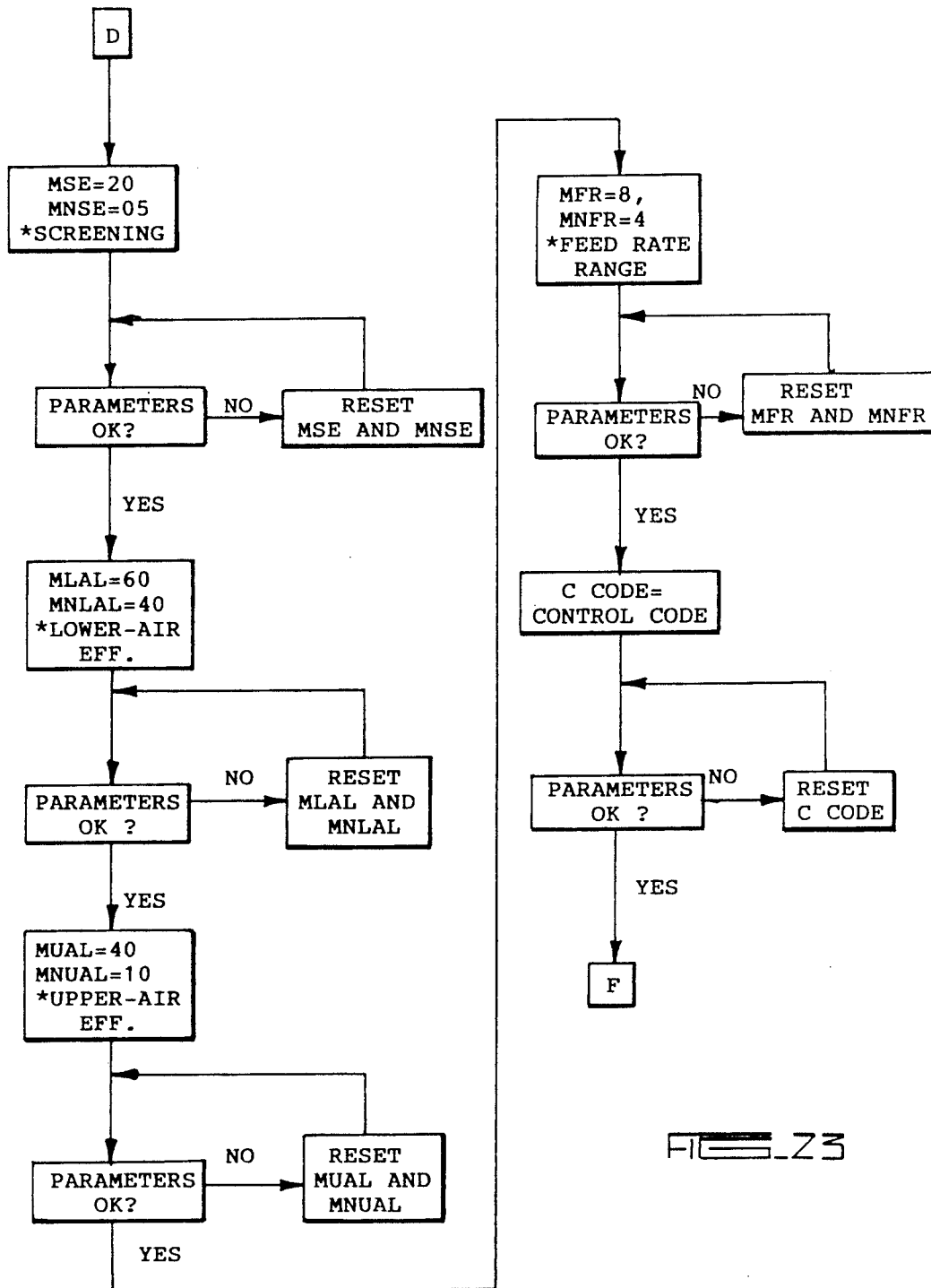


FIG. 23

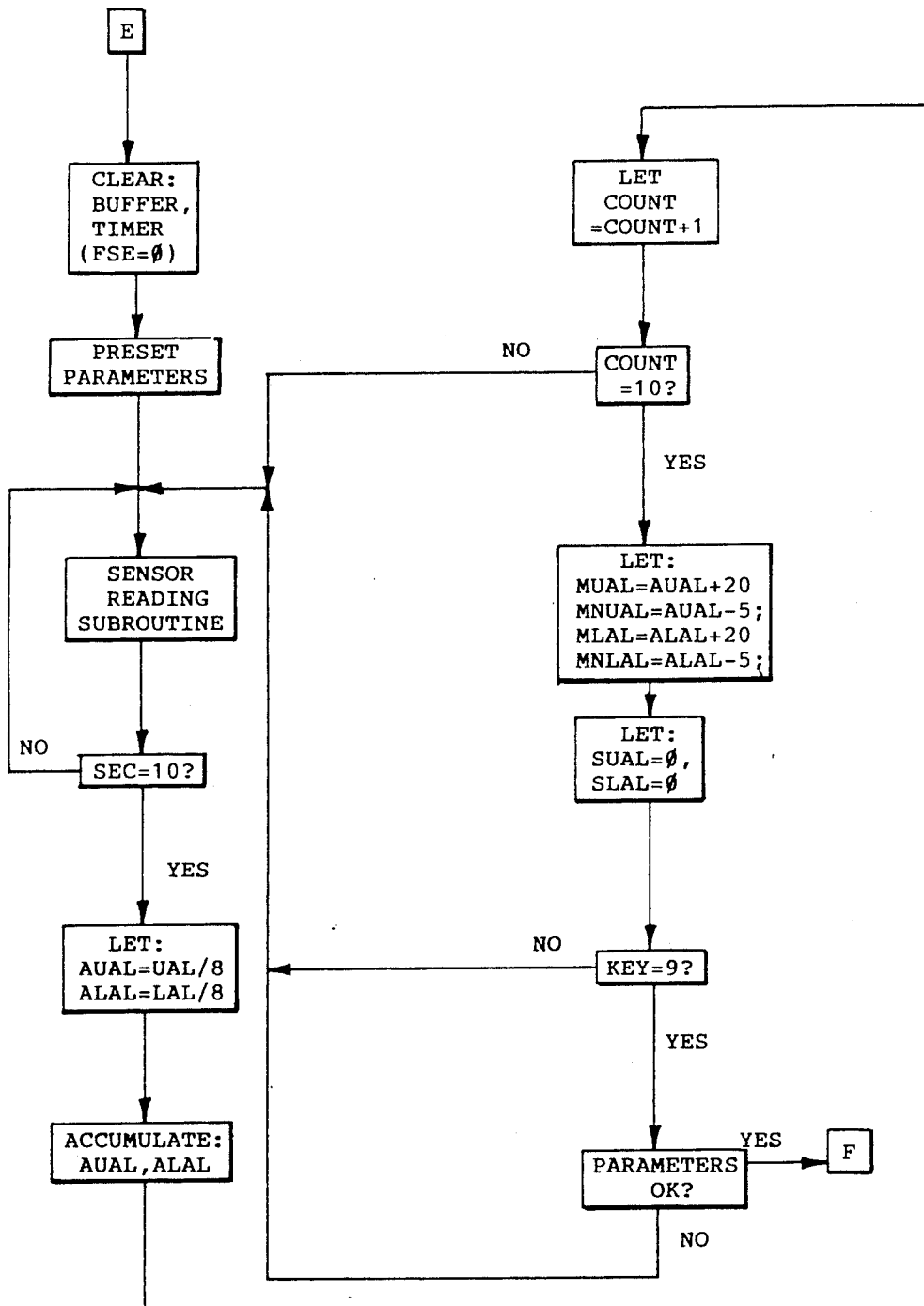


FIG. 24

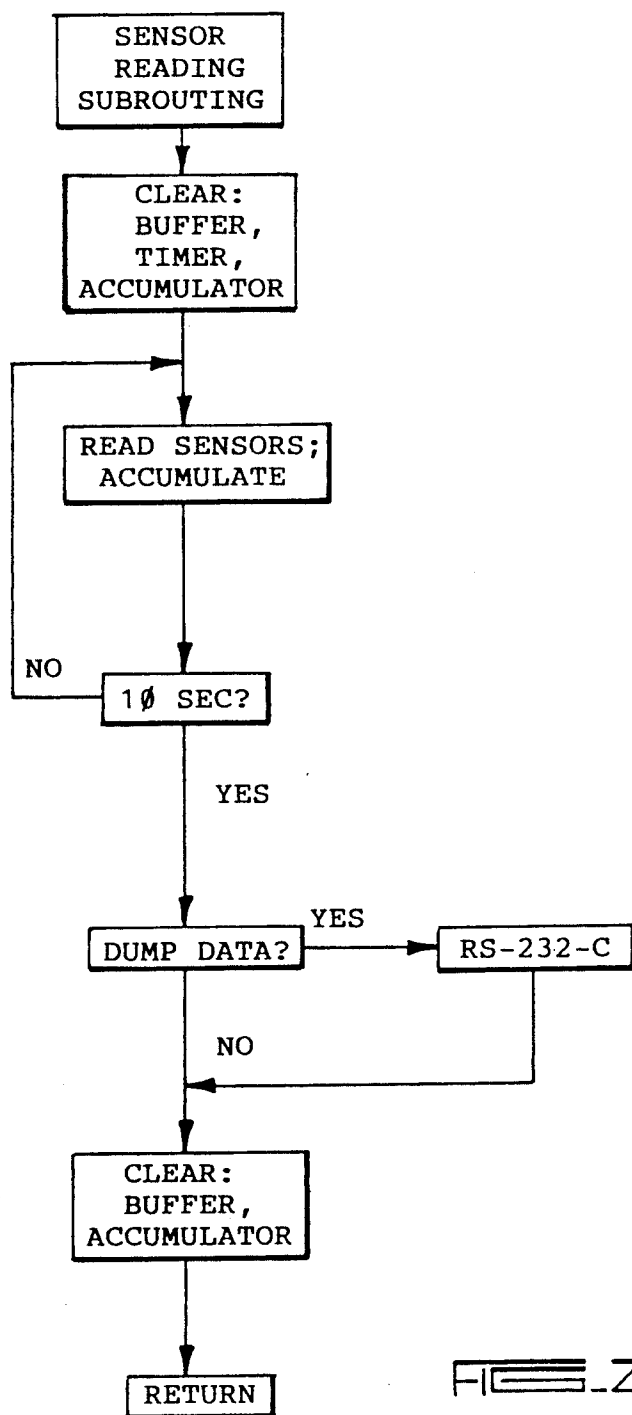


FIG. 25

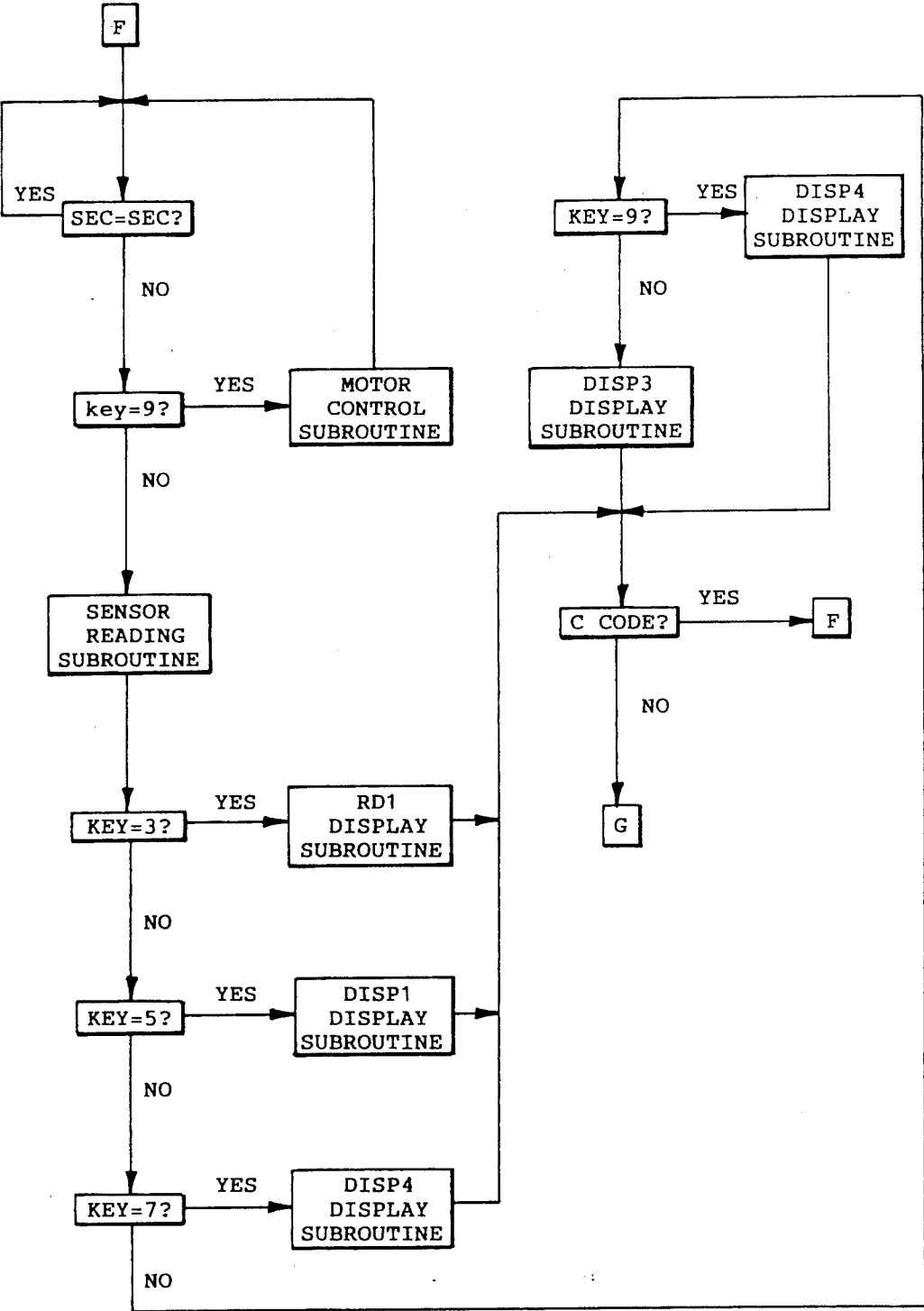


FIG. 26

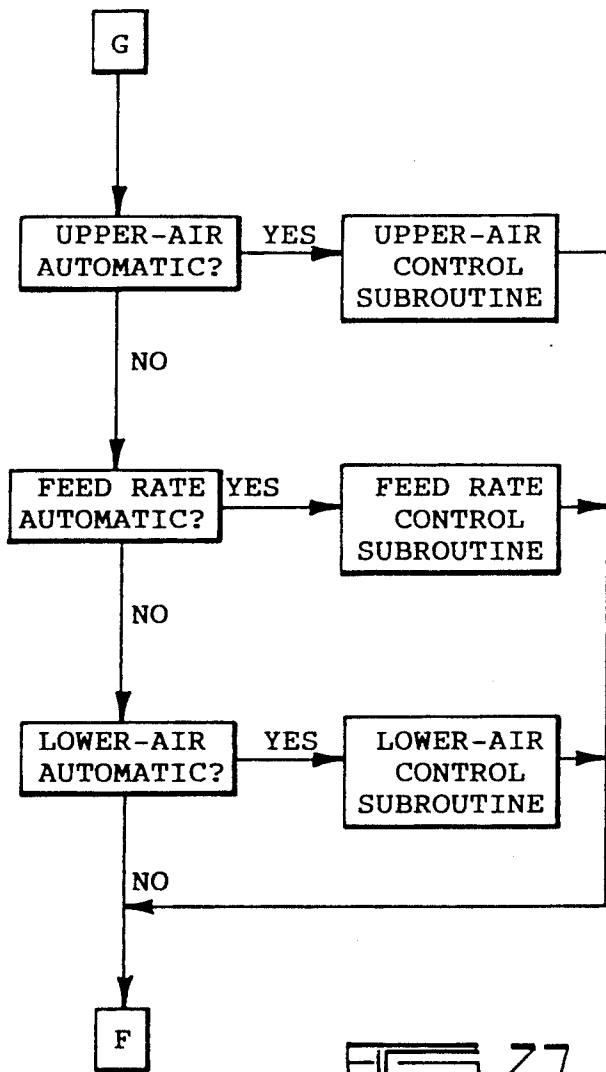
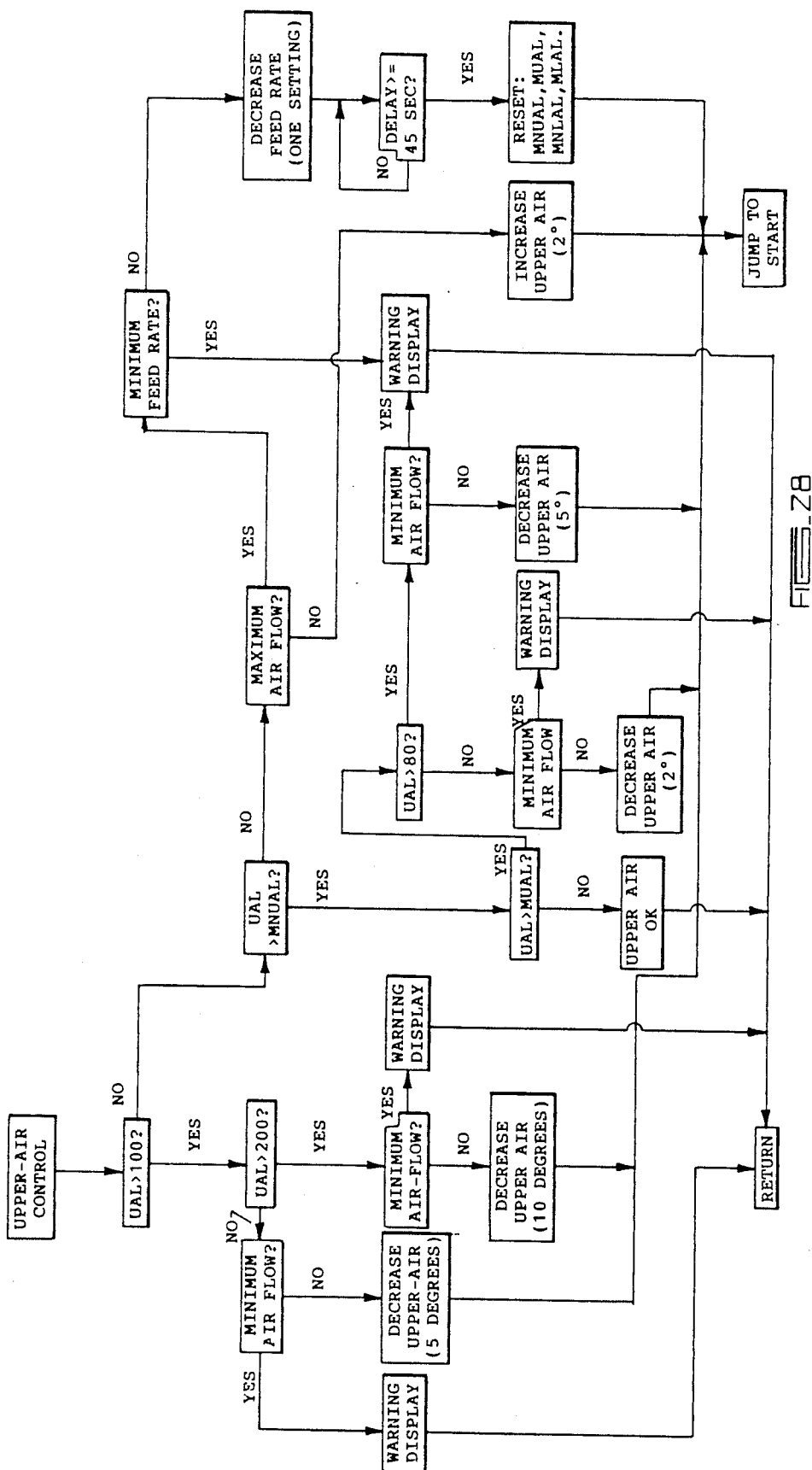
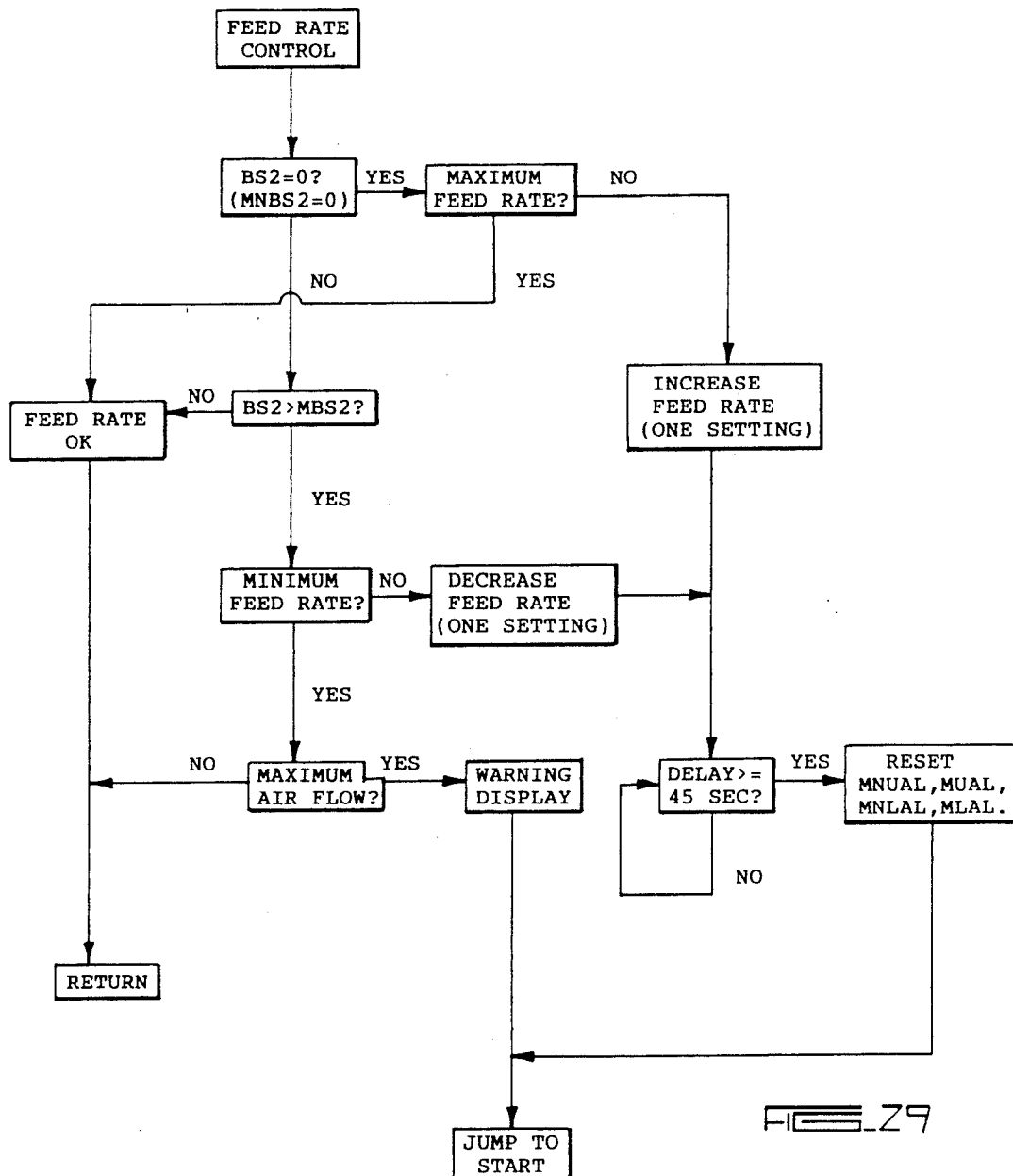
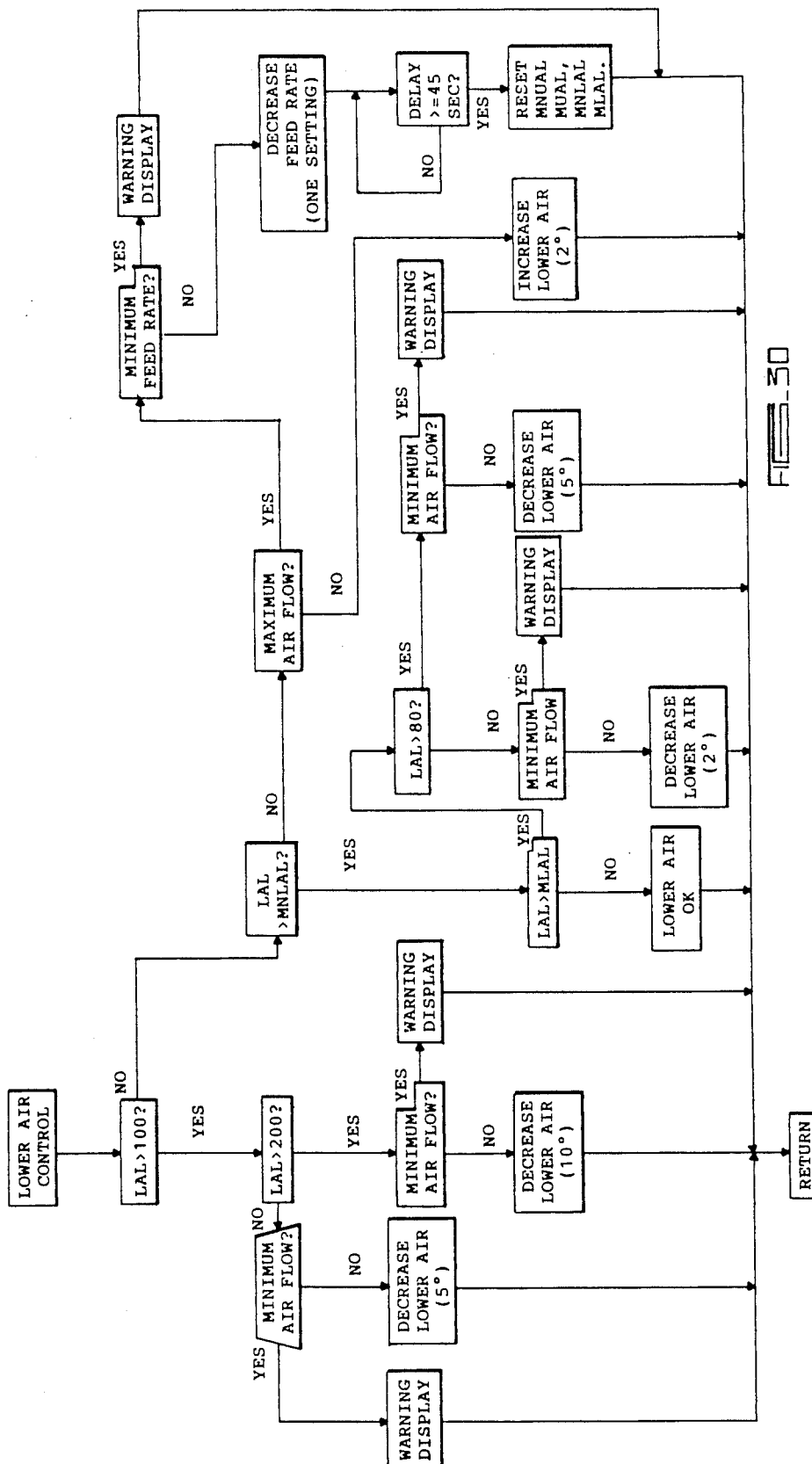


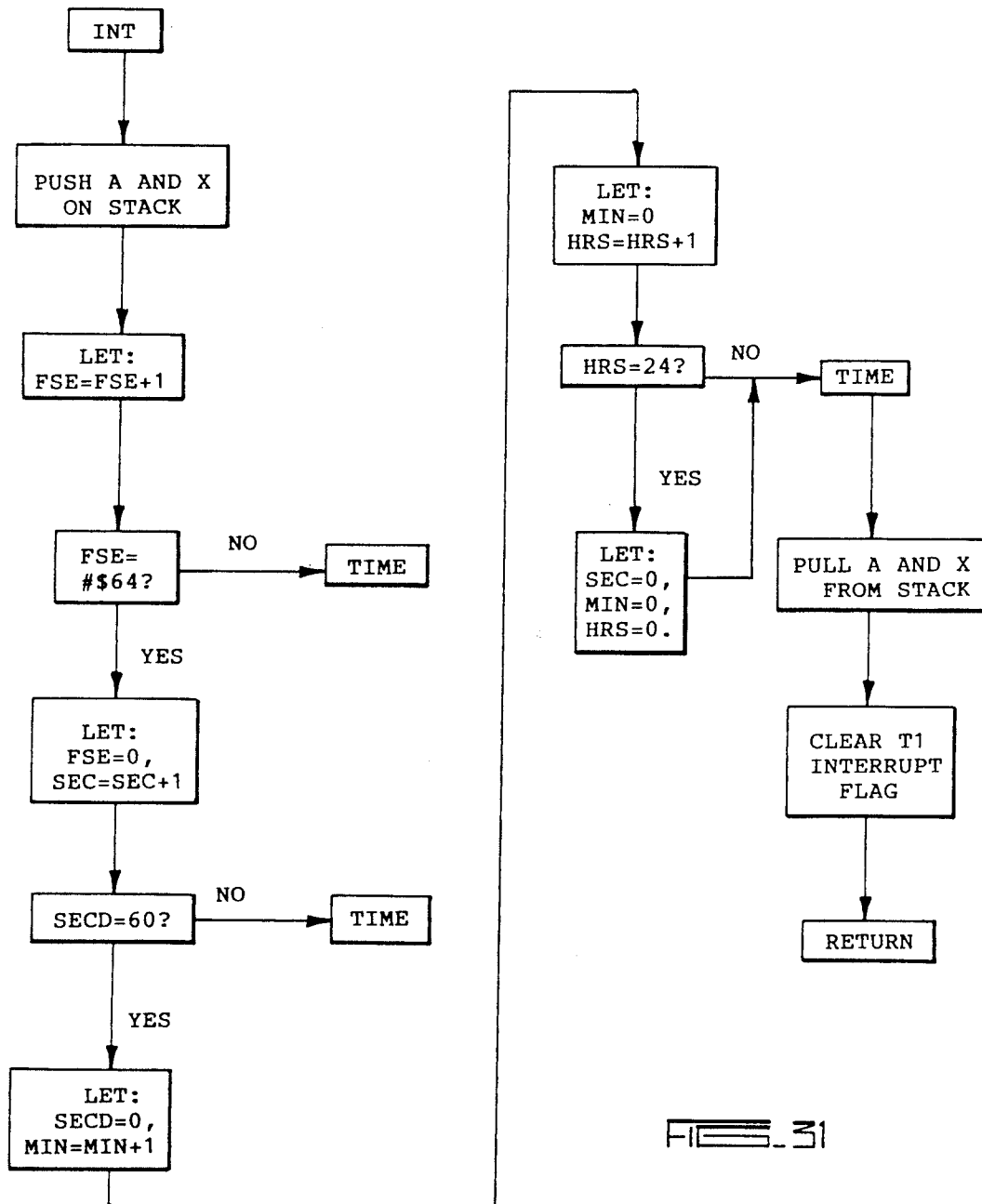
FIG. 27











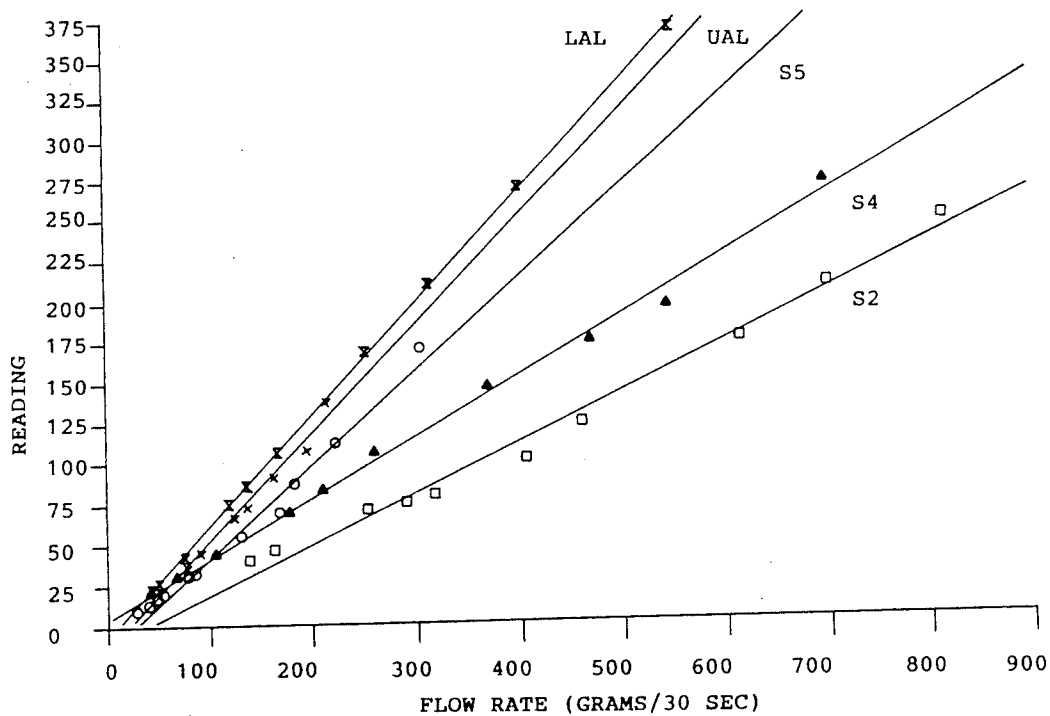


FIG. 32

## AUTOMATION OF AN AIR-SCREEN SEED CLEANER

### BACKGROUND OF THE INVENTION

In seed cleaning operations, the quality of the final seed mixture is an important factor. Conventional seed cleaning systems utilize screens and air to remove foreign matter and other undesirable materials from the desired seeds. Typically, two air separation stages are provided for lifting and removing lightweight materials. The first air-lift is located at the seed hopper and draws a strong stream of air through the entire bulk of seed as it feeds into the cleaning machine. This initial air-lift removes most of the light trashy material from the seed bulk. A second air-lift is normally located adjacent the outlet of the cleaning machine where the cleaned seeds are discharged. This second air-lift removes any remaining light off-grade seeds, hollow kernels, or broken seeds which are not sifted by the screens. The terminal velocity of the seed is an important operating criterion, and proper adjustment of the air-lift is crucial for efficient separation and cleaning.

Typically, at least two screens are also utilized for cleaning the seed. The first or top screen removes coarse foreign material which is larger than the seed, while allowing the seed, dirt, and other small particles to pass through onto the finer second or bottom screen. This second screen retains the clean seed on top, while allowing the foreign material which is smaller than the seed to pass through. The feed rate along the screens must be properly adjusted to obtain maximum and efficient performance.

In these conventional seed cleaning machines, the adjustments of the air-lift vacuum and the screen feed rate are accomplished manually by visual inspection and trial and error. Frequent supervision and adjustment by the operator is necessary to maintain the seed quality with minimum seed loss. Also, such manual adjustments are made at spaced timed intervals, and therefore necessarily attempt to correct problems which have already allowed foreign matter to remain in the finished seed product and/or allowed good seed to be removed with the waste by the screens and air-lift.

Therefore, a primary objective of the present invention is the provision of an improved seed cleaning system which allows for maximization of cleaning efficiency.

Another objective of the present invention is the provision of an improved seed cleaning system which is continuously monitored and adjusted for controlling the efficiency of the operation.

A further objective of the present invention is the provision of a seed cleaning system having an improved air-lift spout.

Yet another objective of the present invention is the provision of a seed cleaning system having an improved screening spout.

Still another objective of the present invention is the provision of a seed cleaning system having a computer processing unit for monitoring and adjusting the seed cleaning operation, if desired.

These and other objectives will become apparent from the following description of the present invention.

### SUMMARY OF THE INVENTION

The present invention improves upon conventional seed cleaning machines having dual screens and dual

air-lifts for cleaning the seed. The improved system includes a computerized processing unit for continuously monitoring the material removed from the seed mixture by the screens and air-lifts and for continuously adjusting the air-lift vacuum and the screen feed rate so as to achieve the desired cleaning efficiency.

The present invention further improves the conventional cleaning system by providing an improved air-lift spout having an inner gate and a standard outer gate for the upper and lower air-lifts. The inner gate is normally open during operation of the system, but will automatically close to maintain the air-lift vacuum when the outer gate is opened to retrieve a sample from the air-lift spout.

The present invention also improves upon the conventional cleaning system by providing an improved screening spout having a divider plate therein adjacent the downstream end of the final screen. The divider plate divides the screening spout into an upstream side and a downstream side, such that the upstream side collects the undersized materials sifted along the substantial length of the final screen, while the downstream side collects the undersized materials sifted immediately adjacent the discharge end of the screen. The presence of any material in the downstream side of the spout indicates that separation along the screen has been incomplete. Accordingly, a single sensor positioned in the downstream side of the screening spout is sufficient for monitoring the screen's operation. Additional sensors along the length of the screen can therefore be eliminated.

The screening sensor produces a signal corresponding to the quantity of undersized material passing through the screen at the discharge end thereof. Similarly, a sensor in the air-lift spout produces a signal corresponding to the quantity of lighter material separated by the air-lift. The sensors are operatively connected to the computerized processing unit which continuously receives and processes the respective signals for monitoring the cleaning operation and for adjusting the extent of separation by the screen and air-lift to achieve a desired efficiency for this system.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view of a conventional seed cleaning machine.

FIG. 2 is a schematic side elevational view of a conventional screening spout.

FIG. 3 is a perspective view of a conventional screening spout.

FIG. 4 is a schematic side elevational view of the improved screening spout of the present invention.

FIG. 5 is a perspective view of the improved screening spout of the present invention.

FIG. 6 is a schematic of a conventional air-lift spout in a closed position.

FIG. 7 is a schematic view of a conventional air-lift spout in an opened position.

FIG. 8 is a schematic view of the improved air-lift spout of the present invention in a closed position.

FIG. 9 is a schematic view of the improved air-lift spout of the present invention in an open position.

FIG. 10 is a schematic representation of the seed cleaning machine of FIG. 1 with sensors, motors, and control units for automating the seed cleaning machine.

FIGS. 11A, 11B, and 11C are top, front, and back schematic views, respectively, of one embodiment of a control unit for the embodiment of FIG. 10.

FIG. 12 is a schematic representation of the electrical connection of the sensors and motors to the circuitry of the control unit of the embodiment of FIG. 10.

FIG. 13 is a block diagram of the inner connection of various elements of one embodiment of a control unit for the system depicted in FIG. 10.

FIGS. 14A and 14B depict schematic representations of the signal conditioning interface or board of FIG. 12.

FIGS. 15A and 15B are schematic representations of one embodiment of sensor selection logic board or sensor logic board of FIG. 12.

FIG. 16 is an electrical schematic of an embodiment for the sensor logic board of FIGS. 15A and 15B.

FIGS. 17A and 17B are schematic representations of one embodiment of the motor logic board or stepping motor logic board of FIG. 12.

FIG. 18 is an electronic schematic of an embodiment of the motor logic board of FIGS. 17A and 17B.

FIGS. 19A, 19B and 19C are schematic tables and representations of an embodiment and function of the stepping motor interface of FIG. 12.

FIGS. 20-31 are schematic flow chart representations of an automatic control program which can be utilized with the invention.

FIG. 32 is a graphic representation of operation of the invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

An air-screening seed cleaner 10 is schematically shown in FIG. 1. Cleaner 10 includes an inlet feed hopper 12, a first set of screens 14A and 14B, a second set of screens 16A and 16B, an upper air-lift 18 and a lower air-lift 20. Air-lifts 18 and 20 are of the vacuum type wherein the vacuum is created by a fan 22 for each air-lift. (Only one fan is shown.) Fans 22 include an adjustable damper 23 for controlling the vacuum created by the fan. The hopper, screens, air-lifts and fans are conventional, and do not form a part of the present invention.

In the operation of a conventional seed cleaner, a mixture of the seed to be cleaned and foreign material is fed into hopper 12 which introduces the mixture onto screen 14A at a fixed rate as determined by a motorized feed wheel 24. As the mixture is fed onto screen 14A, the vacuum in air-lift 18 removes most of the light trashy materials from the mixture, which are collected in a trough or spout 25 for disposal. The oversized rough scalp remains on top of screen 14A while the undersized material, including the desired seeds, passes through screen 14A. A trough or spout 26 at the end of screen 14A collects the rough scalp for disposal. Similarly, screen 14B retains the oversized particles, which includes the desired seed, while the undersized material passes therethrough and is collected in trough or spout 28 for disposal.

As the cleaning operation continues, the desired seed from screen 14B, which still includes a quantity of undesirable foreign matter, passes onto screen 16A. Again, the oversized close scalp is retained on top of screen 16A and collected in a trough or spout 30 for disposal, while the undersized particles, including the desired seed, passes through screen 16A and onto screen 16B. Screen 16B allows fines and splits to pass therethrough which are collected in troughs or spouts 32, 34 for disposal,

while the desired clean seeds are retained on top of screen 16B.

At the discharge end 36 of screen 16B, the cleaned seeds are introduced into the lower air-lift 18 wherein lighter materials, such as off-grade seeds, hollow kernels, or broken seeds, which have not been sifted out by the screens are removed and collected in a spout 38 for disposal. Finally, the clean seeds are discharged through an outlet 40 for collection.

During the cleaning operation, it is desirable to monitor the screening efficiency from the screening spout 34. A conventional screening spout is shown in FIGS. 2 and 3. With the conventional spout, monitoring is difficult since spout 34 collects the undersized screenings from the feed end 42 to the discharge end 44 of screen 16B, as indicated by the arrows in FIG. 3. To overcome this problem, the present invention provides a new design for the screening spout 34, as shown in FIGS. 4 and 5. More particularly, a divider plate 46 is vertically disposed within spout 34 so as to divide the spout into an upstream side 48 and a downstream side 50. Thus, the upstream side 48 collects the undersized material sifted along the substantial length of screen 16B while the downstream side collects the undersized material sifted immediately adjacent the discharge end 44 of screen 16B. Accordingly, the presence of any sifted material in the downstream side 50 of spout 34 indicates that the separation by the screen of the undersized material from the oversized material is incomplete.

It is also desirable to monitor the air-lift efficiency to be sure that desired seeds are not being lifted for disposal rather than remaining on the screens and ultimately dropping for discharge through outlet 40. Lower air-lift spout 38 is structurally and functionally identical to upper air-lift spout 25, therefore only spout 38 will be described.

FIGS. 6 and 7 show a conventional lower air-lift spout 38. Spout 38 typically includes a pivotally mounted gate 52 which normally is pulled shut due to the vacuum within air-lift 20 and spout 38. As the weight of the liftings deposited in spout 38 increases, the weight will push gate 52 open slightly, thereby allowing the liftings to fall out, as indicated in FIG. 6. This slight opening of gate 52 does not significantly effect the operation of air-lift 20. In order to check the quality of the lower air-liftings within spout 38, in conventional operation, the operator manually opens gate 52 and reaches into spout 38 to grab a handful of liftings. However, such opening of gate 52 causes exterior air to be drawn into spout 38 through outlet opening 54 which causes the liftings to be sucked rearwardly away from opening 54, as shown by the arrows in FIG. 7. Furthermore, such opening of gate 52 reduces the vacuum within lower air-lift 20, therefore causing some lightweight materials to fall for discharge through outlet 40.

The present invention provides improved air-lift spouts 25 and 38 having pivotally mounted second interior gates 56, as shown in FIGS. 8 and 9.

In normal operation, as shown in FIG. 8, second gate 56 is normally opened so as to allow the liftings to pass thereby for collection adjacent first gate 52. However, when first gate 52 is opened to retrieve a sample of liftings, the vacuum within air-lift 20 pulls second gate 56 closed, as shown in FIG. 9, so as to prevent exterior air from being drawn into air-lift 20 and so as to maintain the vacuum level within air-lift 20. Thus, the efficiency of the air-lift is not decreased when first gate 52

is opened, as with the conventional spout shown in FIGS. 6 and 7.

As the operation of the screen separation and air-lift separation is monitored, it may be necessary to adjust one or both of these operations so as to achieve the desired cleaning efficiency. Therefore, the present invention provides a first sensor 58 adjacent to downstream side 50 of screen 16B, seen in FIGS. 4 and 5, and a second sensor 60 below second gate 56 of air-lift spout 38, as seen in FIGS. 8 and 9.

Sensor 58 senses the quantity of undersized material received in downstream side 50 of spout 34. Spout 34 includes a plate 62 which allows for gravity flow of the lightweight material onto sensor 58. Sensor 58 produces a signal corresponding to the quantity of lightweight material impacting thereon. An interface 64 receives the signal from sensor 58 and forwards it to a processing unit 66 which then adjusts the screening operation to achieve the desired efficiency of the system, as described hereinafter. More particularly, the processing unit 66 can automatically adjust the rotation speed of feed wheel 24 so that the feed rate of the mixture onto screen 14A is controlled to allow more or less screening separation to be accomplished along screens 14A, 14B, 16A and 16B.

Similarly, sensor 60 in air-lift spout 38 produces a signal corresponding to the quantity of lighter material sensed thereby. An interface 68 receives the signal from sensor 60 and forwards it to the processing unit 66, which then automatically pivots damper 23 within the respective fan 22 so as to adjust the air-lift vacuum to produce more or less separation as necessary to achieve the desired cleaning efficiency.

While sensors 58 and 60 are shown to be an impact sensor, it is understood that other types of sensors can be utilized, such as photo-electric sensors.

FIGS. 10-32 are specifically directed to a preferred embodiment of the invention which utilizes sensors to monitor the seed cleaning process, and computer(s) to gather, compile, and interpret what is detected at the sensors. By merging the sensors and computer control with the previously described advances in the structure of the seed cleaning mechanism, improvement over the art is achieved. Materials of a variety of size, shape, and weight can be sorted efficiently, economically, and accurately.

In the preferred embodiment, sensor monitoring and computer processing allows at least three modes of operation for the invention. As will be discussed in more detail, the invention can merely monitor the operation of the separation of the material, and display the results for the operator, or record and store results over a selected period of time. Secondly, in a semi-automatic mode, the embodiment of the invention can monitor and display separation operation, and inform the operator what changes are desirable to reach the preferred level of separation efficiency. Third, the present invention can be configured to operate autonomously. In this mode, the controlling computer would alter the operation of the separator automatically, to maintain a pre-desired separation efficiency or operation.

It is to be understood that the following is a description of a preferred embodiment only, and that many different configurations of the invention are possible.

FIG. 10 shows a specific preferred embodiment of the invention with monitors or sensors and computer control. Separation hardware is generally the same as is

shown in FIG. 1, and like reference numerals refer to like parts.

FIG. 10 shows motor 100 attached to belt 12 which rotates feed wheel 24. Motor 100 controls the speed of feed wheel 24, which in turn determines the rate at which the material is introduced to the separator. The speed of motor 100 is controlled by motor control 104 such as is known in the art, and which is connected to a 110 volt alternating current source.

A stepper motor 106 is connected to motor control 104 and serves to adjust motor control 104 to in turn adjust speed of motor 100. Stepper motor 106 is in turn controlled by processor or control unit 66.

In the preferred embodiment, motor 100 can be any electrical rotary motor. Stepper motor 106 can be obtained from Japanese Products Corporation, 7 West Chester Plaza, Elmsford, N.Y. 10523 under product designation KP8M2-003 stepping motor, and should have 1.5° per step with 0.41 Nm (58 oz in) dynamic torque.

FIG. 10 also shows two additional stepper motors 108 and 110 which are directly connected and controlled by processor or control unit 66. Stepper motor 108 is operatively connected to damper 112 of upper air fan 114. Stepper motor 110 is operatively connected to damper 112 of lower air fan 22. By connective means such as are known in the art (and not shown) stepper motors 108 and 110 can adjust dampers 112 and 116 in the exhaust of upper and lower fans 114 and 22, to in turn adjust the vacuum created by those fans. Thus, by controlling dampers 112 and 116, the amount of suction or vacuum in upper and lower air lifts 18 and 20 can be controlled.

Stepper motors 108 and 110 can also be obtained from Japanese Products Corporation, under product designation number KP6M2-003 stepping motors. In the preferred embodiment, they would be bigger than stepping motor 106 and would have 0.99 Nm (140 oz in) dynamic torque for controlling the opening of dampers 112 and 116.

It can therefore be seen that each of stepper motors 106, 108 and 110 can control parameters in the separation process which will affect the efficiency of separation.

FIG. 10 also shows that a plurality of sensors can be positioned at certain locations in the separator and transmit signals to control unit 66 so that the efficiency of separation can be monitored. FIG. 10 shows that upper air lift sensor 120 can be positioned in the path of air liftings which are pulled through opening 122 into upper air lift chamber 18 by the vacuum from upper air fan 114. The impacting of air liftings upon upper air lift sensor 120 causes a signal proportionate to the amount of impacting to be generated and sent to control unit 66. By monitoring upper air lift sensor 120 over a period of time, the quantity of upper air liftings being pulled from the material can be derived.

Sensor 58 is positioned so as to monitor the amount of bottom screen materials which are separated from the desired portion of the material. It functions as previously described with respect to FIGS. 4 and 5. By producing a signal proportionate to the amount of screened material impacting upon it, bottom screen sensor 58 sends a signal to control unit 66 which can be used to derive information about the efficiency of separation.

Sensor 60, which will be referred to as lower air lift sensor 60, is positioned within spout 38 for lower air liftings. It operates as described with respect to FIGS. 8

and 9 above, and just as with upper air lift sensor 120, produces a signal proportionate to the amount of air liftings which impact upon it and sends those signals to control unit 66.

In the preferred embodiment of FIG. 10, a clean seed sensor 124 can be positioned directly under outlet 40. It produces a signal proportionate to the amount of clean seed which impacts upon it, and sends that signal to control unit 66. It is also to be understood that a total discard seed sensor 126 can also be utilized to produce a signal proportionate to the total discarded seeds which impact upon it.

Each of the sensors can be what are called impact sensors. Alternatively they can be photo-electric detectors. In the preferred embodiment, the bottom screen sensor 58, lower air lifting sensor 60, and upper air lifting lift sensor 120 are grain loss sensors available from Dickey-john Corporation under the product designation Shoe Sensor, Part No. 10822-0013. The clean seed sensor in the preferred embodiment is also a grain loss sensor from Dickey-john Corporation under the product designation Walker Sensor, Part No. 15491-0001. All sensors can be ordered from Dickey-john Service Center, 6212 East 14th Street, Des Moines, Iowa, or P. O. Box 10, Auburn, Ill. 62615.

It therefore can be seen from FIG. 10, that control unit 66 obtains monitoring information from sensors 58, 60, 120, 124 (and possibly 126). By comparing those signals to predetermined ranges, control unit 66 can issue instructions to stepper motors 106, 108, or 110 to selectively alter feed rate, upper air lift, or lower air lift, according to desire and according to keeping the separation process within the pre-set ranges. Thus, the system can automatically adjust to achieve maximum efficiency of separation.

A preferred embodiment of control unit 66 will now be described. By referring to FIGS. 11A, B and C, control unit 66 includes circuit boards (reference numerals 130, 132, 134, 136, 138 and 140) all of which plug into a common bus 142, and are in electrical connection with a power supply 144, a keyboard 146, and a display 148. All of these elements are contained within a cabinet 150 which includes appropriate power supply plug-ins and communication line plug-ins for attachment of control unit 66 to the sensors, the motors, and other processing equipment, if desired. For example, a 30-pin jack 152 can serve to be connected to a digital communications bus so that data can be sent to other processing equipment (see FIG. 11C). Appropriate sensor jacks 154 receive cables from the sensors utilized in the system. Motor jacks 156 receive plugs from communication cable to stepper motors 106, 108, and 110. Additionally, plugs exist for 5 VDC, 12 VDC, ground (DC) and 110 VAC (see FIG. 11C).

Control unit 66 can also contain miscellaneous control switches or buttons. For example, auto control buttons 158 can be used to select pre-set auto control ranges (see FIG. 11A). Additionally, sensor buttons 160 (see FIG. 11B) can be utilized to bring up on display 148 the instantaneous value for any of the sensors of the system. Other control buttons and features can be incorporated into control unit 66 as are desired.

FIG. 12 schematically depicts the relationship of circuit boards 130, 132, 134, 136, 138 and 140. Board 138 comprises a single board micro-computer, which in the preferred embodiment is a 6502-CPU or 6502A-CPU. The 6502A-Micro-Processor (board 138) contains 72 lines of input/output (I/O), 4K bytes of RAM, 20K

bytes of ROM/EPROM, five timers and two levels of interrupt compressed onto one 11.5 centimeter by 16.5 centimeter standard plug board. The 72 lines of user I/O are configured in logical groups to three edge connectors. Two of the connectors are used for the keyboard/display (reference numerals 146 and 148) and for printer modules. The third connector can be used for other purposes.

Keyboard 146 includes 23 keys, some of alphanumeric nature, and some of multiple function nature. Display 148 consists of a 14-segment fluorescent character display. An on-board 8035 micro-processor (not shown) is also utilized to control display 148, and to interface with CPU 138.

In the preferred embodiment, a Model-6571 input/output expander board 162 is connectable via RS-232C ports to CPU 138, and in turn can be connected to a 20-character, 120 LPM thermal printer (Olivetti PU-1800 Printer) which is not shown.

FIG. 12 shows that signal conditioning interface board 140 receives electrical signals generated by sensors 120, 124, 126, 58 and 60 over separate communication channels 164. Signal conditioning interface 140 is also contained on a standard plug board and is connected to power bus 166, data bus 168, and control bus 170; all of which are interconnected for communication between boards 130, 132, 134, 138 and 140.

Sensor selection logic board 134 contains the necessary circuitry to choose the particular sensor or sensors, for a certain time period, and relay that data to CPU 138.

Stepping motor driver interface board 130 is connected over six channels 172 to various stepper motors. In the preferred embodiment, only three channels 172 are used, namely, for stepper motors 106, 108 and 110. Stepping motor selection logic board 132 then functions with CPU 138 to select which stepping motor will be driven according to the instructions of CPU 138.

Therefore, FIG. 12 shows that processor 66 contains the necessary components to receive the monitoring signals from the sensors, and control operation of the stepping motors according to preset ranges or parameters which are introduced to CPU 138. Processor 66 can also send monitoring information to a printer, or to other processing components, such as a micro-computer, or main frame computer.

FIG. 13 depicts in schematic form, one embodiment of the control and processing components for a separator control system according to the present invention. Again, it can be seen that CPU 138 is the center of the system. FIG. 13 additionally utilizes micro-computer 174 (an Apple III computer) which in turn interfaces with main frame computer 176, printer 178, plotter 180, and disc storage 182. It can therefore be seen that the processing capability of the present invention can expand beyond processor 66. Such additional processing can be utilized to preserve a large quantity of data from the separation process, and allow close and complete analysis of operation of the system.

Specifics regarding boards 130, 132, 134, 138 and 140 of processor 66 will now be described. FIG. 14 schematically depicts the components which would be associated with the signal conditioning interface board 140. As can be seen, ports B,C,D and E receive signals from four sensors (sensors 58, 60, 120, and 124). A +5 volts and ground are supplied through ports "A" and "I", respectively. Board 140 essentially contains components for four or five incoming channels from the sen-

sors, the channels are processed through variable resistors 184, capacitor resistor sub-circuits 186, LM319 components, LM324 operational amplifier, 74LS393N counters, and finally 8212 IC buffered latches. These components receive the sensor signals and condition them to prepare them for reliable and accurate presentation to CPU 138.

FIGS. 15A and B show schematically the components associated with sensor selection logic board 134. Board 134 includes a 74L154 decoder and 7404 converter. Again, the board is powered by +5 volts DC.

FIG. 16 consists of an electrical schematic which sets forth the combined operation of boards 134 and 140. It is to be understood that FIG. 16 is representative of how processor 66 can select a signal from one of the sensors and forward that data to CPU 138. Similar circuitry is utilized for all sensors. FIG. 16 shows three outputs from port B (PB0, PB1, and PB2) are connected to decoder 194 (identified by number 74L154), to allow processor 66 to address eight outputs from the computer program driving processor 66.

FIG. 16 illustrates how the input from a sensor passes through a 0.1 microfarad capacitor to filter out undesirable +5 VDC, which is present in the output of the sensor when there is no load. The sensor signal is then fed to a LM324 operational amplifier (reference numeral 196) which presents a gain equal to the sum:  $1 + (R2/R1)$ . After amplification, the signal is then directed to LM319 comparator 198, which is connected to a 1 kilo ohm potentiometer 200 to allow adjustment and sensitivity of comparator 198.

The output of comparator 198 is sent to 74393 counter 202 which operates to convert the signal to a digital number. The eight output lines from counter 202 are each directed to eight input lines of 8212 buffered latches 204. The data held in buffered latches 204 is transferred to data bus 168 when decoder 194 generates a low voltage signal according to instructions from control bus 170; as the 7404 converter (reference numeral 206) converts the low voltage signal to a high voltage signal which enables the eight output lines of buffered latches 204 to transfer data to the system data bus 168. The software programming takes the data and stores it in memory.

Furthermore, after a selected reading time period for the sensors, the low voltage signals sent through control bus 170 to inputs PB0, PB1 and PB2 of port B of decoder 194. This low voltage signal clears counter 202 and prepares it for the next loop in the program, which will function to direct another reading of the sensors. In the preferred embodiment, board 140 contains signal conditioning for 5 channels (or sensors), whereas board 134 contains signal conditioning for two additional channels (or sensors), plus contains the decoder 194 and converter 206.

FIGS. 17A and B, 18 and 19A, B and C, are electrical schematics for one embodiment of motor logic selection board 132. FIGS. 17A and B shows generally the combination of electronic parts which are operatively connected upon the standard plug board. A 74L154 decoder (reference numeral 208) and a 7404 hex inverter (reference numeral 210) are used on board 132. Three 2N3904 transistors (reference numeral 212), three resistors 214, and three diodes 216 are also utilized. Finally, six relays 218 are included. Resistors 214 comprise one kilo ohm resistors.

Because processor 66 needs to control each of stepper motors 106, 108 and 110, stepper motor selection logic

circuit 132 is utilized to receive the motor control signals from CPU 138, and then select the appropriate stepper motor to be controlled. The signals from board 132 are then sent through stepping motor driving interface board 130 to the appropriate stepping motor.

FIG. 18 shows the exact electronic connection of the various components. It is to be understood that pins PB5 and PB6 receive signals from the system control bus 170 (from CPU 138) and input those signals to decoder 208. Decoder 208 selects which motor is to be controlled by those signals and then transfers the signals from control bus 170 (shown as +B, -B, -A, and +A) through two sets of F2A005 double pole - single throw relays (reference numerals 218) to the desired stepping motor.

FIGS. 20-31 depict in flow chart form, the programming and operational steps which processor 66 can follow during operation of the invention. FIG. 20 depicts the initializing of the program whereby the operator can choose the mode of operation of processor 66. As previously described, the mode can either be set to (a) simply monitor the separator as it functions, (b) semi-automatically monitor and inform the operator of which settings should be maintained to keep operation within certain predesired ranges, or (c) total autonomous control of the operation. In the monitoring mode, data is collected, displayed, and any undesirable situation is conveyed but no actual adjustment is made by processor 66. In any of those three modes, data can also optionally be transferred to another device, and/or stored for record keeping for future analysis.

FIG. 21 depicts the part of the software program whereby the ranges or parameters for the separation process to be automatically controlled are input.

FIG. 25 depicts the operation of the software for obtaining readings from the sensors. Instructions are issued to read all the sensors simultaneously. The readings for each sensor are then accumulated for a pre-selected specified time period (in FIG. 25 the period is set at 10 seconds, but this can be selected according to desire). The software then instructs processor 66 to compare the accumulated value of the upper-air spout sensor 120, and compares it with the pre-entered, pre-selected range. If the value is below the prescribed minimum, or above the prescribed maximum, in the automatic mode, processor 66 adjusts either the damper 112 to upper air fan 114 through stepper motor 108, adjusts the speed of feed wheel 24 through stepper motor 106, or adjusts both. Once the value from the upper-air spout sensor 120 is within the prescribed range, processor 66 checks the accumulated value of the reading from the screening spout sensor or bottom screen sensor 58, and compares that value with the range prescribed for it. If the reading is too high or too low (that is, outside the range), processor 66 adjusts the speed of feed wheel 24 through stepper motor 106 accordingly. Processor 66 then checks the reading from lower air spout sensor 60, and similarly brings the readings within its prescribed range by adjusting damper 116 of fan 22 (to adjust the amount of lower air liftings), or the speed of feed wheel 24, or both.

After this adjustment process, processor 66 loops to repeat the reading of the sensor and the corrections. This process continues in the automatic mode until processor 66 is directed otherwise.

In the preferred embodiment, any time an adjustment of air, in either upper air fan 114 or lower air fan 22 is made, processor 66 initiates another reading of the sen-

sors and loops back to start the correction process over again. On the other hand, if feed rate through feed wheel 24 is changed at any time, processor 66 waits for a specified time period (in the preferred embodiment 45 seconds, or otherwise if desired), and then loops to repeat the process of reading the sensors and correcting. This software routine is depicted in FIGS. 27-30.

Specific parameters used in the preferred embodiment of the invention are described as follows. If the readings at either upper or lower air lifting sensors 120 or 60 are below the minimum pre-set value, and the respective damper of the respective fan is not fully open, the software instructs processor 138 to in turn instruct the appropriate stepper motors to increase air by opening the corresponding damper electro-mechanically. The damper is then opened approximately 2° by the stepper motor, and the result is then checked.

Conversely, if the reading from the appropriate sensor is above the maximum value, air is decreased by closing the respective damper electro-mechanically. The amount of closing of the dampers is related to the difference between the signal read and the maximum value allowable according to the following prescription: 80>reading>max—decrease damper by 2°; 200>reading>max—decrease damper by 5°; and reading>200—decrease damper by 10°. It is to be understood that both the values of "80" and "200" can be changed, as can the degree of damper closing (2°, 5°, or 10°) according to desire. It has been determined that these specifications insure uniformity of seed quality, when the invention is used for seed separation, without loss of good seeds.

Processor 66 also can decrease the feed rate of feed wheel 24 if the reading from either the upper air or lower air sensors 120 and 60 is less than the minimum value assigned, and the damper for the respective fan 114 or 22 is fully opened. If it should occur that the feed rate is already at a minimum, a warning can be issued by processor 66, either through display 148, or by some other alarm means. It is to be understood that the software modifies the values of the optimum sensor reading range if the feed rate is changed during operation.

The feed rate is also decreased if the reading from bottom screen sensor 58 exceeds the maximum allowable value, and the feed rate is above the specified minimum feed rate. Conversely, the feed rate is increased if the reading from bottom screen sensor 58 is below the minimum value (usually 0) and the feed rate is below the specified maximum feed rate.

FIG. 21 again depicts the software programming which allows the invention to have three modes of operation to provide flexibility for the operator. For example, the operator can change the adjustments of

upper air, lower air and feed rate by using keyboard 146 of processor 66. This operation is depicted in FIG. 26. Additionally, the software functions depicted in FIG. 26 allows the operator to display the various sensors' readings at any time by pressing a specific key (for example, pressing key 5 displays the reading of lower air at any time).

By selecting key "0" in FIG. 21, the "completely automatic" mode is selected as depicted in FIG. 22. In the completely automatic mode, processor 66 uses pre-set values as the optimum ranges for operation of the separator.

By selecting key "1" in FIG. 21, the "semi-automatic" mode is selected as depicted in FIG. 23. In this mode, the operator assigns values that are used as optimum values.

Finally, by selecting key "2" in FIG. 21, an "automatic pilot" mode is selected which is depicted in FIG. 24. In this mode, the operator adjusts the machine and the computer maintains the status by measuring the values for a few minutes in the beginning, and computes the range using the average.

FIG. 31 depicts the software flow chart for a 24-hour clock interrupt service routine which is used by the other parts of the software.

Appendix A, attached to this specification, sets forth a specific object code for software according to the invention, and according to FIGS. 20-31. It is to be understood, however, that variations in the programming can be utilized while staying within the boundaries of the present invention. Options and alternatives to the programming can be used, such as are well within the skill of those of ordinary skill in the art.

FIG. 32 graphically depicts the linear relationship between reading of the various sensors of the preferred embodiment of the invention, and increase in flow rate of the material being separated. It can therefore be seen that by adjusting parameters of the separator through the use of processor 66, selected separation output of materials can be achieved.

It will be appreciated that the included preferred embodiment is given by way of example only, and not by way of limitation to the invention, which is solely described by the claims herein. Variations obvious to one skilled in the art will be included within the invention defined by the claims.

It is understood that the cleaning system of the present invention is not limited to seed cleaning, but rather can be utilized for the cleaning of any type of mixture of particulate materials wherein oversized and undersized materials are separated and/or wherein lighter and heavier materials are separated.

Thus, it is seen that the present invention encompasses at least all of the stated objectives.

## APPENDIX A

Auto-Control Main Program.

Program: C000/C9FF

Text: 1000/70FF

Ver: April 28, 1987, *Aray*

OUT=

```

* = 500
RUN * = * + 1
HOUR * = * - 1
MIN * = * - 1
SEC * = * + 1
DECM * = * + 12
VAL * = * - 1
LAL * = * + 1

```

```

* = 50040
NEWSET
JRR CLR
JRR #0
JRR LDR TT.X
JRR OUTPL
JRR CLR
JRR
JRR
OPR #20

```



[illegible]

```

START
LDA SECD
CMP SECD
BEQ START
ACCU
LDA #0FFH
STA PDRA
LDA PDRA
BCR #0FFH
BNE DP
LDA DSTR
DP STA DSTR
CMP #000H
BNE DPA
JSR MOTOR
JMP NOC
DPA
LDA #071H
STA DRB
LDX #0
JSR SENS
LDA #072H
STA DRB
LDX #2
JSR SENS
LDA #073H
STA DRB
LDX #4
JSR SENS
LDA #074H
STA DRB
LDX #6
JSR SENS
LDA #075H
STA DRB
LDX #8
JSR SENS
LDA #076H
STA DRB
LDX #10
JSR SENS
LDA #077H
STA DRB
LDA #078H
STA DRB
LDA SECD
AND #00FH
CMP #0
BEQ CONT
JMP ACCU

```

```

CMP #2
BEQ MOT2

```

```

DP1 CMP #020H
BNE DP2
JSR DISPA1
JMP CLEN
DP1 CMP #010H
BNE DP2
JSR DISPA4
JMP CLEN
DP2 CMP #008H
BNE DP3
JSR PDC
JMP CLEN
DP3 JSR DISPA1
CLEN
LDA DMCHK
CMP #001H
BNE NODM
JSR DUMP
NO DM
LDA CCODE
AND #004H
CMP #4
BEQ AUUA
JMP FRCH
AUUA
SED
LDA DECM+10
CMP #000H
BEQ CHUA1
INC TEMUA
LDA TEMUA
CMP #2
BEQ DEUA
JMP FRCH
CHUA1
LDA UAL
CMP MUUA
BCS CHUA1
MTUA
NOP
PHA
JSR URI
LDX #0
LDA #018H
STA DRB
MTUA1 LDA #0FFH
STA TSEC
MTUA1
LDA #008H
STA DRB
LDA TSEC
BNE MTUA2
INX
CRX #6
BNE MTUA1
MOT2
LDA #048H

```

```

C1
LDA #2
BCR #000H
STA CANG
JMP NOC
URI LDX #2
JSR ILR
RBI LIR AB
JSR LUTPU
INX
CRX #00H
BNE RB1
C1
CHUA LDA UAL
CMP MUUA
BIS DEUA
JMP FRCH
DEUA PHA
JSR CRB
LDX #8
LDA #010H
STA CRB
MTUA1 LDA #0FFH
STA TSEC
MTUA2 LDA #000H
STA DRB
LDA TSEC
BNE MTUA2
INX
CRX #6
BNE MTUA1
LDA #077H
STA CRB
LDA #078H
STA DRB
PLA
BEQ
LDA CANG
BCR #2
STA CANG
LDA #0
STA TEMUA
JMP NOC
FRCH LDA CCODE
AND #002H
CMP #2
BEQ AUUA
JMP FRCH
AUUA
LDA DECM+4
CMP #0
BEQ CHUA1
INC TEMUA
LDA TEMUA
CMP #2
BEQ RDE

```

```

JMP AIR
HFR1
LDA B52
CMP #00
BNE U1
LDA FR
CMP MFR
BEQ AIR1
JSR S0
INC FR
CLC
PHA
LDA #005
ADC MNLAL
STA MNLAL
LDA #050
STA DRB
LDA #0FF
STA TSEC
MOT1A
LDA #040
STA DRB
LDA TSEC
BNE MOT1A
PLA
JMP NFR
AIR1 LDX #0
AIR1A LDA AIR1B,X
JSR OUTPUT
INX
CPX #20
BNE AIR1A
JMP LACH
U1
LDA B52
CMP M5E
BCD AIR2
MOT2
LDA FR
CMP MNFR
BNE MOT2B
JMP STOP
MOT2B
LDA ANG
CMP #090
BCD DEMF1
JSR F0
DEMF2
DEC FR
SEC
PHA
LDA MNLAL
SBC #005
STA MNLAL
LDA #050
STA DRB
LDA #0FF
STA TSEC

```

```

STA DRB
LDA TSEC
BNE MCT2A
PLA
JMP NFR
DEMF1 LDX #0
DEMF2 LDA DEMF2,X
JSR OUTPUT
INX
CPX #20
BNE DEMF2
LDA FR
SBC #1
STA MFR
JMP DEMF2
AIR2 JMP LACH
NFR
NOP
LDA #077
STA DRB
LDA #070
STA DRB
JSR NFR1
PHA
LDX #0
NFRAR
LDA #0FF
STA TSEC
NFRAR
LDA TSEC
BNE NFRAR
INX
CPX #40
BNE NFRAR
PLA
JMP NOC
NFR1 PHA
LDX #0
JSR CLR
NFR2 LDA NF,X
JSR OUTPUT
INX
CPX #20
BNE NFR2
PLA
RTS
RD1 LDX #0
JSR CLR
LDA CCODE
CMP #7
BEQ RDA
CMP #6
BEQ RDB
CMP #5
BEQ RDC
CMP #4
BEQ RDD

```

```

CMP #2
BEQ RDF
CMP #1
BEQ RDG
JMP RDH
RDA LDA RDA1,X
JSR OUTPUT
INX
CPX #20
BNE RDA
RTS
RDB LDA RDB1,X
JSR OUTPUT
INX
CPX #16
BNE RDB
RTS
RDC LDA RDC1,X
JSR OUTPUT
INX
CPX #16
BNE RDC
RTS
RDD LDA RDD1,X
JSR OUTPUT
INX
CPX #12
BNE RDD
RTS
RDE LDA RDE1,X
JSR OUTPUT
INX
CPX #16
BNE RDE
RTS
RDF LDA RDF1,X
JSR OUTPUT
INX
CPX #12
BNE RDF
RTS
RDC LDA RDC1,X
JSR OUTPUT
INX
CPX #12
BNE RDC
RTS
RDA LDA RDA1,X
JSR OUTPUT
INX
CPX #14
BNE RDA
RTS
STOP NOP
PHA
LDX #0
JSR CLR

```

```

STOP1 LDA STOPR,X
JSR OUTPUT
INX
CPX #20
BNE STOP1
PLA
LDA ANG
CMP #990
BEQ WORST
JMP LACH
WORST LDX #0
WORST1 LDA WORSTA,X
JSR OUTPUT
INX
CPX #20
BNE WORST1
LDA FR
STA FR
JMP NOC
LACH LDA COODE
AND #801
CMP #1
BEQ AIR
JMP NOC
AIR
LDA DECM+2
CMP #990
BEQ CHLA1
INC TEMPLA
LDA TEMPLA
CMP #2
BEQ TUR1A
JMP NOC
CHLA1
LDA LAL
CMP MNLAL
BCS X1
JSR MTLA
JMP NOC
TUR1A CMP #1
BNE TUR1B
JMP TUR2
TUR1B JMP TUR1
MTLA
NOP
SED
CLC
LDA ANG
CMP #990
BCS DEMP
LDA #2
ADC ANG
STA ANG
CLD
PHA
JSR #0
LDA #938
STA DRB
LDX #0
MTLA1 LDA #FFF
STA TSEC
MTLA2
LDA #923
STA DRB
LDA TSEC
BNE MTLA2
INX
CPX #6
BNE MTLA1
LDA #977
STA DRB
LDA #970
STA DRB
PLA
RTS
DEMP
JMP MOT1
URB PHA
JSR CLR
LDX #0
URB1 LDA UR,X
JSR OUTPUT
INX
CPX #20
BNE URB1
PLA
RTS
R0 PHA
JSR CLR
LDX #0
R01 LDA R,X
JSR OUTPUT
INX
CPX #20
BNE R01
PLA
RTS
X1 LDA LAL
CMP MLAL
BCS NOCR
CMP #990
BCS TUR1
LDA #5
STA TURNW
LDA #2
STA ANGN
JMP TUR3
NOCR
JMP NOC
TUR1
LDA #25
STA TURNW
LDA #10
STA ANGN
JMP TUR2
TUR2
LDA #13
STA TURNW

```

```

LDA #5
STA ANGN
TUR3
JSR MTL5
JMP NOC
MTL5 NOP
SED
SED
LDA ANG
SED ANGN
STA ANG
CLD
JMP OVER
LDA #930
STA DRB
LDX #0
MTLB1 LDA #FFF
STA TSEC
MTLB2
LDA #920
STA DRB
LDA TSEC
BNE MTLB2
INX
CPX TURNW
BNE MTLB1
LDA #977
STA DRB
LDA #970
STA DRB
PLA
RTS
OVER PHA
JSR CLR
LDX #0
OVERB LDA OVER1,X
JSR OUTPUT
INX
CPX #20
BNE OVERB
PLA
RTS
NOC
LDA TEMPLA
CMP #2
BNE NOCKLA
LDA #0
STA TEMPLA
NOCKLA
LDA MIN
CMP #5
BNE NONEW
LDA #0
STA TEMUA
STA TEMPLA
NONEW
LDA #0
LDA #0

```

```

REP2 STA DECM,X
INX
CPX #17
BNE REP2
RECHK
LDA SECD
AND #40F
CMP #0
BNE RECHK
JMP START
SDATA JMP START
DELAY LDY #0
DEL INY
JSR DESK1
CPY #41F
BNE DEL
RTS
IIR0 PHA
LDA #3FF
STA TSEC
SEC
CLC
LDA #1
ADC FSEC
STA FSEC
CMP #464
BNE TIME
LDA #0
STA FSEC
STA TSEC
CLC
LDA #1
ADC SECD
STA SECD
CMP #460
BNE TIME
LDA #0
STA SECD
CLC
LDA #1
ADC MIN
STA MIN
CMP #460
BNE TIME
LDA #0
STA MIN
CLC
LDA #1
ADC HOUR
STA HOUR
CMP #24
BNE TIME
TIME LDA T1CL
PLA
RTI
DISP0 JSR CLR
LDX #0
DISP0A LDA DISP0,X
JSR OUTPUT

```

```

INX
CPX #13
BNE DISP0A
LDA CCODE
JSR NUMA
JSR READ
CMP #400
BNE NCODE
RTS
NCODE
JSR RCHECK
JSR RDRUB
ASL A
ASL A
ASL A
ASL A
AND #400
STA CCODE
JSR RCHECK
JSR RDRUB
AND #40F
CLC
ADC CCODE
STA CCODE
JMP DISP0
DISP1 JSR CLR
PHA
LDA #400
JSR OUTD
LDA CCODE
JSR NUMA
LDA #420
JSR OUTD
LDX #0
DISP LDA MESS0,X
JSR OUTPUT
INX
CPX #7
BNE DISP1
LDA HOUR
JSR NUMA
LDA #1
JSR OUTD
LDA MIN
JSR NUMA
LDA #1
JSR OUTD
LDA SECD
JSR NUMA
LDA #420
JSR OUTD
PLA
RTS
DISP2
JSR CLR
LDX #0
DISP21 LDA DISP2A,X
JSR OUTPUT

```

```

INX
CPX #10
BNE DISP21
LDA FR
JSR NUMA
LDA SETP
CMP #440
BNE DISP2P
RTS
DISP2R
JSR READ
CMP #400
BNE NFEE0
RTS
NFEE0 JSR RCHECK
JSR RDRUB
ASL A
ASL A
ASL A
ASL A
AND #4FF0
STA FR
JSR RCHECK
JSR RDRUB
AND #40F
CLC
ADC FR
STA FR
JMP DISP1
DISP3 JSR CLR
LDA #0
DISP31 LDA DISP3A,X
JSR OUTPUT
INX
CPX #15
BNE DISP31
LDA UANG
JSR NUMA
JSR READ
CMP #400
BNE NUP
RTS
NUP JSR RCHECK
JSR RDRUB
ASL A
ASL A
ASL A
ASL A
AND #4FF0
STA UANG
JSR RCHECK
JSR RDRUB
AND #40F
CLC
ADC UANG
STA UANG
JMP DISP0
DISP4 JSR CLR
LDX #0

```

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```

DSPL1 LDA DSRLA,X
JSR OUTPUT
INX
CPX #15
BNE DSPL1
LDA ANG
JSR NUMA
JSR READ
CMP #40D
BNE NLOW
RTE
NLOW JSR RCHECK
JSR RDRUB
ASL A
ASL A
ASL A
ASL A
AND #4F0
STA ANG
JSR RCHECK
JSR RDRUB
AND #40F
CLC
ADC ANG
STA ANG
JMP DISPL
DISP1 JSR CLR
LDX #0
DSP31 LDA DSP3A,X
JSR OUTPUT
INX
CPX #4
BNE DSP31
LDA DECM+10
JSR NUMA
LDA DECM+11
JSR NUMA
LDA #420
JSR OUTD
LDA #420
JSR OUTD
LDX #0
DSP32 LDA DSP3B,X
JSR OUTPUT
INX
CPX #4
BNE DSP32
LDA DECM+2
JSR NUMA
LDA DECM+3
JSR NUMA
LDA #420
JSR OUTD
RTE
DISP4 JSR CLR
LDX #0

```

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```

DPUNA LDA DIUN,X
JSR OUTPUT
INX
CPX #7
BNE DPUNA
LDA MNUL
JSR NUMA
JSR READ
CMP #400
BNE DPUAL
RTE
DPUAL JSR CLR
LDX #0
DPUMA LDA DIUM,X
JSR OUTPUT
INX
CPX #5
BNE DPUMA
LDA MLAL
JSR NUMA
LDX #0
DPUNA LDA DIUN,X
JSR OUTPUT
INX
CPX #7
BNE DPUNA
LDA MNUL
JSR NUMA
JSR READ
CMP #400
BNE DPUAL
RTE
DISP5 JSR CLR
LDX #0
DSP51 LDA DSP5A,X
JSR OUTPUT
INX
CPX #10
BNE DSP51
LDA DMCHK
JSR NUMA
JSR READ
CMP #400
BNE NDM
RTE
NDM JSR RCHECK
JSR RDRUB
AND #40F
STA DMCHK
JMP DISP5
F0 PHA
LDX #0
F02 LDA F0A,X
JSR OUTPUT
INX
CPX #20
BNE F0A
PLA
RTE

```

```

50 PHA
LDX #0
50A LDA DEC+1,X
JSR OUTPUT,
INX
CPX #20
BNE 50A
PLA
RTS
50B PHA
CPX #0
BNE 501
LDA DRA
AND #FF0
STA HEXA
JMP 50
501 LDA DRA
STA HEXA
JMP 50
502
JSR HEXD
CLC
LDA HEST+1
ADC DEC+1,X
STA DEC+1,X
BCC LOOP
INC DEC,X
LOOP CLC
LDA HEST
ADC DEC,X
STA DEC,X
CPX #0
BEQ SCLS
CPX #2
BEQ SLAL
CPX #4
BEQ SBS2
CPX #6
BEQ STOTAL
CPX #10
BEQ SUAL
PLA
RTS
SUAL LDA DEC+1,X
STA UAL
PLA
RTS
SBS2 LDA DEC+1,X
STA BS2
PLA
RTS
SLAL LDA DEC+1,X
STA LAL
PLA
RTS
SCLS LDA DEC+1,X
STA CLS
PLA

```

```

STOTAL LDA DEC+1,X
STA TOTAL
PLA
RTS
HEXD SED
LDA #0
STA HEST
STA HEST-1
LDA HEXA
AND #FF0
CMP #50A
BCC NEXT
CLC
ADC #0
NEXT STA HEST-1
LDA HEXA
AND #F0
BEQ NEXT1
CLC
LDA #F0
ADC HEST+1
STA HEST+1
NEXT1 LDA HEXA
AND #20
BEQ NEXT2
CLC
LDA #32
ADC HEST+1
STA HEST+1
NEXT2 LDA HEXA
AND #40
BEQ NEXT3
CLC
LDA #64
ADC HEST+1
STA HEST+1
BCC NEXT3
INC HEST
NEXT3 LDA HEXA
AND #80
BEQ NEXT4
CLC
LDA #20
ADC HEST+1
STA HEST+1
BCC NEXT4
INC HEST
NEXT4 INC HEST
NEXT5 NOP
RTS
DUMP NOP
PHA
SED
LDX #0
LDY #0
LDA DEC-1
AND #FF0
SEL 0

```

```

STA TH
LDA DEC-2
AND #FF0
SEL 0
LDA 0
LDA 0
LDA 0
LDA 0
ORA TH
STA TH
JSR ASCI
LDA DEC-1
AND #FF0
SEL 0
SEL 0
SEL 0
SEL 0
STA TM
LDA DEC-1
AND #FF0
SEL 0
LDA 0
LDA 0
LDA 0
CPX TM
STA TM
JSR ASCI
LDA #20
JSR WAIT
LDA #44
JSR WAIT
LDA #44
JSR WAIT
LDA #54
JSR WAIT
LDA #44
JSR WAIT
LDA #20
JSR WAIT
LDA 0
JSR ASCI
LDA #20
JSR WAIT
LDA UANG
JSR ASCI
LDA ANG
JSR ASCI
LDA #20
JSR WAIT
LDX #0
MPA LDA DEC,X
JSR ASCI
INX
CPY #2
BNE TO
LDA #20
JSR WAIT
LDY #0

```

```

RTS
BNE MP1
LDA #40D
JSR WAIT
LDA #40A
JSR WAIT
PLA
RTS
ASCI PHA
LSR A
LSR A
LSR A
LSR A
JSR MP2
PLA
AND #40F
MP2 CLC
ADC #430
CMP #430
BCC WAIT
CLC
ADC #1
JSR WAIT
RTS
WAIT PHA
MP1 LDA CTRL
AND #401
BEQ MP3
PLA
STA DR1
RTS
MOTOR NOP
PHA
ENTER
LDA #470
STA DRB
LDX #0
LDA #4
STA KEYM
JSR CLR
ENT1 LDA ENT1A,X
JSR OUTPUT
INX
CPX #20
BNE ENT1
JSR READ
CMP #431
BEQ ADJUA
CMP #432
BEQ ADJLA
CMP #40D
BNE ENTER
JMP NEXM
ADJUA LDA #0
STA MTCON
JSR CLR
LDX #0

```

```

ADJUA LDA ADJUA,X
JSR OUTPUT
INX
ASL A
ASL A
CPX #20
BNE ADJUA1
JMP DIRCH
ADJLA LDA #420
STA MTCON
JSR CLR
LDX #0
ADJLA1 LDA ADJLA,X
JSR OUTPUT
INX
CPX #20
BNE ADJLA1
JMP DIRCH
DIRCH LDA #40F
STA FDRP
JSR CLR
LDA FDRB
BCR #4FF
BNE MT1
LDA KEYM
MT1 STA KEYM
CMP #40
BNE MT2
LDA MTCON
ADC #408
STA DRB
JMP DIRCH
MT2 CMP #408
BNE MT3
LDA MTCON
STA DRB
JMP DIRCH
MT3 CMP #420
BNE MT4
JMP ENTER
MT4 LDA #470
STA DRB
LDA #477
STA DRB
LDA KEYM
CMP #480
BEQ NEXM
JMP DIRCH
NEXM LDA #480
STA DSTR
JSR RD1
PLA
RTS
ENT1A .BYT (ADJ UA=1
      ADJ LA=2
ADJUA .BYT (UPPER AI
R: 81-UA-02

```

```

ADJLA .BYT (LOWER AI
R: 81-LA-02
DIRCH .BYT (CONTROL
DEB1
MESS .BYT TIME=
R .BYT INCREASE
OVER #1
TO INX
CPX #12
OVER1 .BYT (WARNING:
OVER MAX LAL
FEED .BYT (* INCREASE
FEED RATE)
F01 .BYT (WARNING: PO
OR FISTING)
RB .BYT (* INCREASE
UPPER AIR)
NF .BYT (*CHANGING P
EE1 WAIT
OVERB1 .BYT (WARNING:
OVER MAX UAL
CLEAN .BYT (CLEAN SO
(BL H0)=
STOPA .BYT (* MINIM
UM FEED RATE)
DSP1A .BYT FEED FAT
E
AIR1B .BYT (* MAXIM
UM FEED RATE
DEMPA .BYT (*ANG=90
MAX FR=FR-1
DSP1A .BYT EE1=
DSP4B .BYT EE2=
W0R5TH .BYT (* CHEC
K CLEANER) **
RD1 .BYT (AUTOMATE
UA FR/LA
RD2 .BYT (AUTOMATE
UA FR
RD01 .BYT (AUTOMATE
UA LA
RD01 .BYT (AUTOMATE
UA
RD1 .BYT (AUTOMATE
FR/LA
RD1 .BYT (AUTOMATE
FR
RD1 .BYT (AUTOMATE
LA
RD1 .BYT (AUTOMATE
NONE
DSP1A .BYT UAL=
UA .BYT (WARNING: OVE
R MAX UAL
DSP1A .BYT (DUMP DAT
A (YES=1)
DIRB .BYT (B32 MAX=

```





```

ASL A
AND #$F0
STA MNAL
JSR RCHECK
JSR RDRUB
AND #$0F
CLC
ADC MNAL
STA MNAL
JMP ASK2A
ASK1
LDX #0
QUE31 LDA QUE3N2
JSR OUTPUT
INX
CPX #7
BNE QUE35
LDA MNAL
JSR NUMA
JSR READ
CMP #$00
BNE NMNLA
JMP ASK2A
NMNLA
JSR RCHECK
JSR RDRUB
ASL A
ASL A
ASL A
ASL A
AND #$F0
STA MNAL
JSR RCHECK
JSR RDRUB
AND #$0F
CLC
ADC MNAL
STA MNAL
JMP ASK2A
ASK2A
JSR CLR
LDX #0
QUE31 LDA QUE3N2
JSR OUTPUT
INX
CPX #8
BNE QUE31
LDA MNAL
JSR NUMA
JSR READ
CMP #$00
BNE NMNLA
JMP ASK2
NMNLA
JSR RCHECK
JSR RDRUB

```

\*51  
LDA RPT  
STACK

```

ASL A
ASL A
ASL A
ASL A
AND #$F0
STA MNAL
JSR RCHECK
JSR RDRUB
AND #$0F
CLC
ADC MNAL
STA MNAL
JMP ASK2A
ASK2
LDX #0
QUE32 LDA QUE3N2,X
JSR OUTPUT
INX
CPX #7
BNE QUE32
LDA MNAL
JSR NUMA
JSR READ
CMP #$00
BNE NMNLA
JMP ASK2
NMNLA
JSR RDRUB
ASL A
ASL A
ASL A
ASL A
AND #$F0
STA MNAL
JSR RCHECK
JSR RDRUB
AND #$0F
CLC
ADC MNAL
STA MNAL
JMP ASK2A
ASK2
JSR CLR
LDX #0
QUE32 LDA QUE3N2,X
JSR OUTPUT
INX
CPX #8
BNE QUE32
LDA MSEE
JSR NUMA
JSR READ
CMP #$00
BNE NMSE
JMP ASK2
NMSE
JSR RDRUB

```

```

ASL A
ASL A
ASL A
ASL A
AND #$F0
STA MSEE
JSR RCHECK
JSR RDRUB
AND #$0F
CLC
ADC MSEE
STA MSEE
JMP ASK2
ASK4
LDX #0
QUE34 LDA QUE3N4,X
JSR OUTPUT
INX
CPX #9
BNE QUE34
RPT4 JSR READ
CMP #$00
BNE RPT4
ASK5 JSR CLR
LDX #0
QUE35 LDA QUE3N5,X
JSR OUTPUT
INX
CPX #9
BNE QUE35
LDA MFR
JSR NUMA
JSR READ
CMP #$00
BNE NMFR
JMP ASK5
NMFR JSR RCHECK
JSR RDRUB
AND #$0F
STA MFR
JMP ASK5
ASK5
LDX #0
QUE35
LDA QUE3N6,X
JSR OUTPUT
INX
CPX #8
BNE QUE35
LDA NMFR
JSR NUMA
JSR READ
CMP #$00
BNE NMNFR
JMP $C046
NMNFR JSR RCHECK
JSR RDRUB
AND #$0F

```

```

TSEC  ***-1
HEST  ***-2
HEWA  ***+1
DETR  ***+1
KEYM  ***+1
DIR   ***+1
MTCON ***+1
TH    ***+1
TM    ***+1
CORE  ***+1
      **$B112
      JMP $D0000
      **$D0000
      LDA #000
      STA MLAL
      LDA #040
      STA MNLAL
      LDA #040
      STA MUAL
      LDA #010
      STA MNUAL
      LDA #020
      STA MSE
      LDA #005
      STA MNSE
      LDA #4
      STA FR
      LDA #0
      STA MFR
      LDA #2
      STA MNFR
      LDA #430
      STA ANG
      LDA #00
      STA CCODE
      LDA #040
      STA UANG
      LDA #001
      STA DMCHK
      LDX #0
      JER CLR
TIT   LDA TITL,%
      JER OUTPUT
      INX
      CPM #20
      BNE TIT
      JER DELAY
      JER CLR
      LDX #0
NAME  LDA NAME,%
      JER OUTPUT
      INX
      CPM #20
      BNE NAME
      JER DELAY
      JER CLR
      LDX #0

```

```

RECEIVE DA REMEM 0  

GET OUTPUT  

INQ  

CPRN #28  

BNE REME  

LDA #486  

STA DSTR  

LDA #483  

STA STR  

LDA #443  

STA TTR  

LDA #472  

STA UTR  

LDA #6  

STA DDOR  

LDA #493  

STA DDOR  

LDA #408  

STA RCR  

LDA #408  

STA LCR  

LDA #477  

STA CRB  

LDA #478  

STA CRB  

LDA #5  

LDA #5  

RECL STA HOUR.W  

INQ  

CPRN #21  

BNE RECL  

LDA #486  

STA DSTR  

LDA #486  

STA TCOL  

LDA #420  

STA TACH  

LDA #C1IR0  

STA IR0V  

LDA #D1IR0  

STA IR0V+1  

OLI  

LDA #6  

STA COUNT  

STA MSLAL  

STA LSLAL  

STA NSUAL  

STA LSUAL  

STA AMLAL  

STA ALLAL  

STA AMUAL  

STA ALUAL  

START  

LDA BEED  

CMP BEED  

BEQ START

```

THE COUNT

RE: [REDACTED]

[illegible]

```

JMP NOC
DELAY LDY #8
DEL JER DEBK1
INY
CPY #4FF
BNE DEL
RTS

```

```

CHKLA
LDA AMUAL
SEC SETUA
LDA #499
STA MUAL
LDA #499
STA MNUAL
JMP CHKLA
SETUA
CLC
LDA ALUAL
ADC #428
STA MUAL
BOC SETMU
LDA #499
STA MUAL

```

We claim:

1. An improved cleaning system for separating lighter material from heavier material in a mixture of particulate materials, the system including an inlet for receiving the mixture, an outlet for discharging heavier material, and a vacuum air-lift means between the inlet and the outlet for separating the lighter material from the heavier material, the air-lift means having a spout for collecting the lighter material and having a first gate movable between a normal closed position for maintaining the vacuum of the air-lift means and a second open position for discharging the lighter material, the improvement comprising:

a second gate in said air-lift spout mounted upstream from the first gate and being movable between a normal open position when the first gate is closed and a closed position when the first gate is open; and

a sensor for sensing the quantity of lighter material separated by the air-lift means, the sensor being mounted in the spout downstream from the second gate so that when the second gate is in the open position, the lighter material separated by the air-lift means enters the spout and passes the second gate for sensing by the sensor.

2. The cleaning system of claim 1 wherein the second gate is pivotally mounted in the spout so as to automatically move to the closed position by the vacuum of the air-lift means when the first gate is open.

3. The cleaning system of claim 1 wherein the sensor produces signals corresponding to the quantity of lighter material sensed by the sensor, and the sensor is interfaced with a processing means for receiving and processing the signals for monitoring the cleaning system and for adjusting the extent of separation by the air-lift means to achieve a desired efficiency of the system.

4. The cleaning system of claim 1 further comprising at least one elongated screen for separating undersized material from oversized material, the screen having a

```

SETMU
LDA ALUAL
CMP #7
BOC EQ8
SEC #5
STA MNUAL
JMP CHKLA
EQ8 LDA #2
STA MNUAL
CHKLA
LDA AMLAL
SEC SETLA
LDA #499
STA MLAL
LDA #499
STA MNLAL
JMP FINISH
SETLA
CLC
LDA ALLAL
ADC #428
STA MLAL
BOC SETML
LDA #499

```

```

STA MLAL
SETML
LDA ALLAL
CMP #7
BOC EQ1
SEC #5
STA MNLAL
JMP FINISH
EQ1 LDA #2
STA MNLAL
FINISH
JMP #C040
DSP4A .BYT 'BS1='
DSP4B .BYT 'BS2='
DSP3A .BYT 'UAL='
DSP3B .BYT 'LAL='
AVE1 .BYT 'AV UAL='
AVE2 .BYT 'LAL='
TITL .BYT 'DATA READ
& AVER PGM'
REM1 .BYT '*** DATA
READING ***'
NAM .BYT 'BY SHYY'

```

feed end and a discharge end, and a screening spout adjacent the discharge end for collecting the undersized material sifted through the screen,

a divider plate mounted in the screening spout so as to divide the screening spout into an upstream side and a downstream side, the upstream side collecting the undersized material sifted along the substantial length of the screen and the downstream side collecting the undersized material sifted immediately adjacent the discharge end of the screen, whereby the presence of undersized material in the downstream side of the screening spout indicates that the separation by the screen of the undersized material from the oversized material is incomplete; and

another sensor mounted in the downstream side of the screening spout for sensing the quantity of undersized material collected therein.

5. The cleaning system of claim 4 wherein the another sensor produces signals corresponding to the quantity of undersized material sensed by the another sensor and the another sensor is interfaced with a processing means for receiving and processing the signals for monitoring the cleaning system and for adjusting the extent of separation by the screen to achieve a desired efficiency of the system.

6. A method for separating desire material from undesirable material in a mixture of particulate materials, comprising:

introducing the mixture onto a first screen means for separating undersized material from oversized material within the mixture, the screen means having a feed end and a discharge end;

sensing the quantity of undersized material separated by the screen means adjacent the discharge end thereof and generating a signal corresponding to such quantity;

depositing the oversized material into an air-lift

means for separating lighter material from heavier materials within the oversized materials; sensing the quantity of lighter materials separated by the air-lift means and generating a signal corresponding to such quantity; 5 adjusting the extent of separation by the screen means and the extent of separation by the air-lift means in response to the respective generated signals so as to achieve a desired cleaning efficiency; and sampling the separated lighter materials to determine the quality thereof. 10

7. The method of claim 6 wherein the adjustments are made by a processing unit which receives and processes the respective signals.

8. The method of claim 6 further comprises dividing the discharge end of the screen means into an upstream side and a downstream side, the sensing of the quantity of undersized materials occurring only on the downstream side of the discharge end of the screen means. 15

9. The method of claim 6 wherein the sampling further includes opening a first gate and closing a second gate within said air-lift means so as to maintain the vacuum therein, the sample being located between the first and second gates. 20

10. The method of claim 9 wherein the closing of the second gate is automatic and simultaneous with the opening of the first gate. 25

11. The method of claim 6 further comprising receiving any of said generated signals with a processing means. 30

12. The method of claim 11 further comprising presenting a user of the method with official information from said processing means regarding and corresponding to the generated signals. 35

13. The method of claim 11 further comprising interpreting the generated signals with the processing means and instructing a user how to adjust any of the introduction and separation of material to cause the method to achieve desired separation of undesirable material from desirable material.

14. The method of claim 11 further comprising automatically adjusting with the processing means any of the introduction and separation of material on a continuous, automatic basis to achieve pre-set separation of undesirable material from desirable material.

15. The method of claim 11 further comprising controlling operation of one or more motors in response to the generated signals.

16. A method of separating an undesired portion from a desired portion of a mixture of various size, shape and weight materials, comprising the steps of:

feeding material into a separator means at a first rate of feed; separating at least some of the undesirable portion of the material from the desirable portion of material in the separator means;

sensing the quantity of undesirable material which is separated from the desirable material in the separator means;

adjusting at least one of the set of feed rate of the material and separation of the material to change the separation process; and

sampling the separated undesirable portion of materials to determine the quality thereof.

\* \* \* \* \*